PELICAN BOOKS

THE PHYSICAL BASIS OF PERSONALITY

V. H. MOTTRAM

About This Book

PERSONALITY is conditioned by two main factors—environment and heredity. It is with the second of these that this book is mainly concerned.

Attempting to bridge the gap between the biological and the theological viewpoints regarding the reasons for the uniqueness of the individual, it discusses and explains in non-technical language the mechanism of physical inheritance in the living cell, the arrangement and behaviour of the chromosomes, sex determination, Mendelian inheritance and its laws in plant, animals and man, the constitution and working of the sympathetic and parasympathetic systems and their influence on individuality, and the part played by the endocrine organs in personal make-up.

The few technical terms used are carefully explained in a glossary compiled specially for the reader who approaches the subject for the first time.

"A brilliant description of genes, glands, chromosomes, all the physical causes which go so far to shape personality . . . Millions of wasted words since Darwinism struck the gong for the fight between Science and Religion would have been saved if this kind of approach had been made oftener from both sides of the great divide."—*John o' London's Weekly.*

"The experiences of the mystic interest him as much as the discoveries of the biologist. His philosophy is wide enough to cover them both."—*Times Educational Supplement.*

"From the first page he is on terms of friendship with his reader, writing with his accustomed directness, wit and judgement, and with beautiful modesty."—*Lancet.*

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BY

V. H. MOTTRAM

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Perhaps it will again call attention to the need for bridging the chasm. And if it stirs some more adequate pontifex to bridge-building, so much the better.

I am indebted for much help in the portions dealing with cytology to Dr. Ingold, of University College, Leicester, though any errors therein, as elsewhere in the book, are "all my own work".

I have also to thank Mrs. Brocklebank of Donhead Hall for help in constructing the glossary.

Leicester, 1944. V. H. M.

CHAPTER I

INTRODUCTORY

How far is personality determined, or at least modified, by the physical attributes of a person? Does the body determine the personality or does the personality in any way determine the physical make-up of the person? We are all apt, for example, to excuse an unpleasant assemblage of qualities in a person on the grounds that he is the unhappy possessor of a gastric or duodenal ulcer. A weakness or mishap to the physique, with the discomfort and pain ensuing, may distort the personality. On the other hand it is a commonplace of medicine that the strenuous, energetic, restless, ambitious personality is singularly prone to gastric ulcer. In a less outspoken way we note that the personality of a man writes its signature on the lines of his face. It was a fair generalisation twenty-five years ago that in the mid-westerner of the United States the corners of the mouth turned down whereas in the New Englander they turned up.

Probably there is an influence in both directions though, I imagine, there are few who would deny that much of a man's personality depends on the make-up of the body he inherits. It is difficult (though nor impossible) to have a dominating personality if one is a dwarf, and it is unlikely that a woman masculinised by some abnormality of the suprarenal body or of the gonads could achieve a maternal character. Our task is to discover in how far the physical make-up determines personality.

Now personality can hardly be denied to animals, though doubtless a philosopher would cavil at such an extension of the term. Most dog-lovers would certainly apply it to the objects of their affections. The epithet "craven-coward" has been used by Collip, the biochemist, of a wolf-hound after he had removed the animal's pituitary gland, and the animal was restored to its native personality of aggressiveness by treatment with extracts of that gland. It is difficult not to use a personal term of such an animal or to deny that the animal's personality was determined by the secretion of the pituitary gland. Of course, it is a projection of the attributes of personality in man upon animals, but it seems to be a reasonable projection.

Any observer of animals must have seen reactions in them which demanded, almost, the projection upon them of terms usually used to describe the characteristics of human beings. Pavlov, the great Russian physiologist, descried in his dogs characters reminiscent of the humours of Galenic medicine—the phlegmatic, the sanguine and so on—and it is difficult not to descry in them hysteria and neurasthenia, so closely do their reactions resemble those of human beings.

In such lowly animals as frogs there are indications of marked differences not only in external appearance but in reactions which one is tempted to term psychological. They will behave differently towards artificial feeding—some will accept it, others will put up marked resistance. (Indeed, some forty years ago, in the days of Tariff controversies, the writer named one of his animals "Joseph" because he so strongly objected to foreign imports.)

In the poultry yard something markedly akin to personality is seen. A hen, in the absence of a normal mate, may take upon herself the dominance of the hen run, behaving in many ways with the arrogance and aggressiveness of a cock. I have not only observed this but a change over from marked masculine attributes to the meekest of femininity on the introduction into the fowl run of a squire. The reverse change has been described by Crew (and incidentally much earlier by the Roman historian Livy). A hen, after a year of normal henny characteristics had become dominating and cocky in her relations with the rest of her sisters, but in this instance, not only did the hen imitate the male in her protective care of the other dames but she grew cocky feathers, comb and spurs and actually begat a number of chickens before her sacrifice on the altar of genetics, when it was discovered that avian tuberculosis had destroyed her ovaries and that from undifferentiated germinal tissue she had grown testes. Her psychology and her sex had changed *pari passu* as the result of a clinical mishap—a clear instance of personality, if you will forgive the term as applied to a hen, being based upon physical make-up.

These instances of the influence of physical changes on the behaviour pattern of animals are given first because much of our knowledge of the influence of the endocrine organs (the so-called glands of personality) has been obtained by experiments upon animals and only later confirmed by observations upon man, and second, because most biologists believe, and increasingly are

driven to believe, that the whole realm of living things shows a strange unity of plan. Life, almost, is one and indivisible. This is not to say that there are not striking differences between, for example, man and the louse which feeds on him and transmits to him the infection of typhus fever. None the less the pattern of the chemistry and physics of the living cell, whether it be a yeast cell or one of the cells of the metazoa, is fundamentally similar. To take an example: a peculiar enzyme is essential to the life of the yeast cell. The suspicion that the same or closely similar co-enzyme is essential to man solved the century-old enigma of the cause of the disease pellagra. Instances could easily be multiplied, so that the biologist might well echo Walt Whitman:

"A vast similitude interlocks all . . .
All lives and deaths, all of the past, present, future,
This vast similitude spans them, and always has spanned
And shall for ever span them and compactly hold and enclose them."

We cannot—we of the United Nations—but believe in the intense importance of personality. We have no use for the bee-hive state with its sex-frustrated workers wearing themselves to death (for what?), with its massacres of queen larvæ by the successfully fertilised queen, with its isolation and starvation to death of the aged and inefficient queen and its autumn holocaust of drones. That is a pattern of life which might easily become ours—would become ours in a Fascist regime.

We cannot but believe that our civilisation has marched more and more towards the recognition of the value of personality, and our ideal surely is that the individual should develop this personality to the fullest extent compatible with the development of the personalities of his fellows. So far as man can step aside and observe his nature and history objectively, they are characterised by a progressive change towards the regard for personality. In western civilisation this is not astonishing, for, unchristian as our civilisation may seem at any moment, it is based upon Christianity and its march is towards Christian ideals. (Further back still, embedded in Jewish religion, we find emphasis on the individual. One can, for example, hardly love one's neighbour as oneself—Leviticus xix. 18—and be a wholehearted Nazi or Fascist.) And, it seems to the writer, that the worth of the individual is a cardinal point in the Christian religion. It is implicit in the parables, in the relation of Jesus to, for example,

the Samaritan woman, in "are not five sparrows sold for two farthings?", in his mission which caught into its net rich, poor, taxgatherers, courtesans, the élite and the outcast. And in the long and tragic history of the Church, when, from lust of pomp and power, it had fallen away from the doctrines of its founder, those who revived its energies put in the forefront of their message the worth of the individual soul. Hitler's war is not so much a war for dominance of the world by one particular nation—it is not the old type of clash of national sovereignties—but a war between two ideals: one which recognises the right of the individual to develop the personality to the full and the other which would insist on his subordination to the state and of the world to a self-constituted Herrenvolk. Fortunately the United Nations are on the side of individual value, though by no means all the Fascists are with the Axis powers. We most of us have a little Fascist hidden in our hearts.

Now no one can doubt that personality is largely determined on the one hand by environment and nurture and, on the other hand, by physical endowment. Environment and nurture have made the young Nazi the arrogant and truculent person he is, and it is the Nazi success in indoctrinating the young which sends all our doctrinaires chasing off into a youth movement—to dominate it of course. With environment and nurture, however, we are hardly concerned, except in a secondary way, in this book. What concerns us is the influence of physical endowment upon personality and the way in which physical endowment is determined by inheritance. No one can doubt that physical endowment influences, perhaps even determines, personality. The phrase "big, blonde, brute" comes to mind. It is difficult to have a dominating personality if one is intensely ugly or is a tiny individual—though, it must be admitted, there are exceptions to this generalisation—Queen Victoria, for example. The tall are often shy and retiring; the short bumptious and self assertive. The artistic personality often goes with a particular shape of hand, and so does the practical with another.

Our first subject for discussion is how physical endowment is inherited. We have all known families whose members were more unlike each other, both in physique and temperaments, than are unrelated people. An extraordinary case is that of unidentical twins one of whom was tall, blue-eyed and red-headed and the other short, black-haired and brown-eyed. At first, and quite superficially, it might appear that inheritance

plays little part in producing physical endowment, and yet we know that it does. The "family face" descends from generation to generation—e.g. the Hapsburgh lip, which was first figured in the fifteenth or sixteenth century and certainly characterised the late ex-King Alfonso of Spain. It is known that hair colour, eye colour, albinism and a number of queer abnormalities such as colour-blindness, lack of a power of the blood to coagulate when shed, and alkaptonuria are inherited according to definite laws. As regards these inherited abnormalities we know that they must influence the personality. Imagine the effect of being colour-blind. The person so afflicted can see little in spring or autumn landscape to stir him—a whole page or more of nature is simply torn from his sight, nor can he understand many of the passions of poet and artist. And when, like Eugene Carrière, he has inherited an artistic temperament along with colour-blindness the effect on the personality must be almost tragic.

Tragic indeed is the inheritance of hæmophilia, and with consequences sometimes leaping far beyond the unhappy individual. We do not know how the personality of the late Tsarevich was and would have been influenced by his inheritance of hæmophilia—lack of the power of blood to coagulate—but we do know that that circumstance led to the waste of millions of helpless Russians in the war of 1914–17, to the fall of the Romanoff dynasty and the rise of the U.S.S.R. Physical make-up is of prime interest and importance, and the more we can learn of its inheritance the better. Personality is grounded upon physical make-up and so the inheritance of make-up—or better, physical endowment—must be our first line of study.

CHAPTER II

The Cell

We cannot study the physical basis of inheritance without first studying the cell. All living things—we are considering the more complicated forms more particularly—are built up of little units called cells. "There is," Sherrington writes, "a little aggregate of atoms and molecules such as the world we call lifeless nowhere contains. It is confined to living things; many of these it enters into as a unit, and builds up. It is a unit with

individuality. Taken singly it behaves as an entire life. In many cases it does constitute of itself an entire life, although but a pin's point in size. Even where the individual is massive it consists, for the longer part of its duration, of many of these tiny units massed together. But its life story still begins with just a single one of them."[1]

Its life story—*our* life story—still begins with just a single one of them. "Each of us still at the outset of his or her individual life story is microscopic and one sole cell. By that cell's multiplication, and by its descendants' coherence, each of us attains his or her final form and size."[2] Seeing then that all our inherited characteristics—our chance of personality—is handed down by that one single cell, the cell must be our first consideration.

That we are made of cells, perhaps fifteen thousand millions or more of them, has been for a hundred years or more no longer a theory but a fact. The microscope demonstrates it. When there has been some doubt of this independence one of another, as in the nervous system, experimentation has upheld this independence.

This variation in size and shape is prodigious. They may be small, round, and biscuit shaped, as for instance the red cells of the blood. Nearly sixteen thousand of these could be packed one deep on a pin's head. They may be cubical, or approximately so, but larger, as is the liver cell. It is roughly 25μ across, whereas the red blood cell is 8μ.[3] A muscle cell may be about the same in diameter as the liver cell, but its length is much greater. It may be three millimetres long. But a nerve cell may be much longer. Take a nerve cell which activates the muscles of a finger. Its central and head office may be situate in the cervical swelling of the spinal cord but its long life line to the finger muscles may be a yard in length. Compared with that of a red blood corpuscle the length of a nerve fibre, which is an outgrowth and part of a nerve cell, is "miles long"—if one wants a figure: one-eighth of a million times longer.

As in length so in multiplicity of form. Not only may cells be disc-shaped, spherical, cubical, columnar, and micellar, but they may be star-shaped, spider-like, bracket-shaped, filiform or

[1] Sherrington, *Man on his Nature*, p. 69, Cambridge University Press, 1942.

[2] Sherrington, *ibid.*

[3] μ = one thousandth of a millimetre, which is roughly one twenty-fifth of an inch.

branched like a tree. These shapes are the norm in the nervous system. The cell has to make contact near and far, so it stretches out myriads of tendrils to touch its neighbours and often one long branch to carry messages afar.

With all this enormous difference in size and shape, cells are built to a general scheme and for our plan all we need consider is a "generalised" cell, an idea or abstraction of a cell based on a study of the shapes and forms and contents of all the cells in the body.

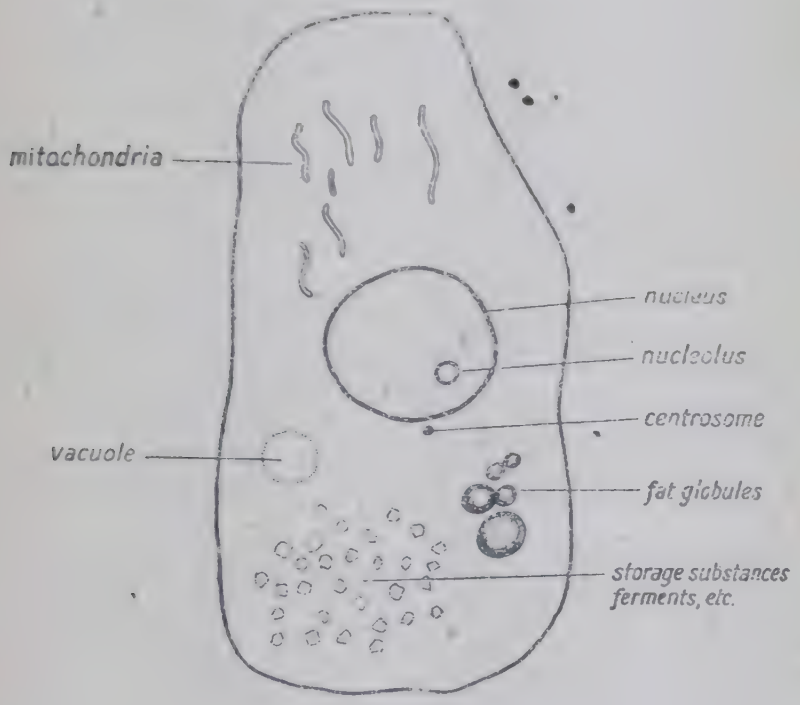


FIG. 1
Schematised diagram of cell

The cell consists of a small speck of living fluid or jelly (protoplasm), spherical, cuboidal, polyhedral, and over its surface is a film or membrane—though not a skin. Inside the cell is included, among the globules of fat, granules of glycogen and vacuoles containing fluid, one or more structures called a nucleus. Most cells have one only; some cells, e.g. liver cells, have two or three; a muscle cell (fibre) may have a thousand.

Since the protoplasm of this nucleus or kernel has different chemical properties it gets a distinguishing name, "nucleoplasm" —or better, karyoplasm—while the protoplasm of the rest of the cell is called "cytoplasm". The nucleus has a particular interest for us, apart from its action as director of the cell's energies and co-ordinator of its activities. It, and possibly, even probably, it alone is the carrier of hereditary characteristics. This visible kernel in the cell is "a central nest of ferments. Remove it from the cell and the cell's rest gets out of gear and dies."[1] In the living cell it appears structureless, rather like a transparent Rugby football, filled with a viscous fluid in which there is a glass marble—the nucleolus—capable of rolling about. Only when the nucleus is about to divide into two, in cell division, or when it is killed, do other structures within it appear —a network just within its surface, called the chromatin network because it stains deeply with many of the dyes used by those who research on cell structure (the cytologists or, generally speaking, histologists).

This slaughter of the cell by poisons such as mercuric chloride, potassium dichromate, formalin, alcohol and so on with subsequent staining of the cell with aniline or other dyes has given us considerable knowledge of the structure of the cell and particularly its nucleus when dead. Fortunately discoveries of this nature can be controlled on the living cell by watching it in a surviving state under "dark ground illumination". In dark ground illumination the light of the microscope lamp is shot very obliquely and from all sides upon the object under investigation, which then becomes visible as a glowing structure seen against a dark ground. The object can be a cell or so dug out of a living tissue, kept alive in a nutrient fluid in conditions of oxygenation and temperature similar to those of the body from which it was taken. Such cells continue to live and grow and can be observed in their processes of assimilation, growth, dissimilation, excretion and division indefinitely. Indeed the descendants of a piece of heart muscle dug out of a hatching hen's egg are still under observation though the original tissue was abstracted some thirty years ago. Under such illumination we can make sure whether structures seen in the dead cell are a product of killing fixation and staining or whether they exist in "life".

[1] Sherrington, *Man on his Nature*, p. 80.

As said above, it is the nuclear structures which concern us most, those of the cytoplasm being of less importance to our study. The cytoplasm structures comprise oil globules, granules (storage products, ferments, etc.), vacuoles, Golgi apparatus, mitochondria and a centrosome. The mitochondria are often thin mobile threads which appear most active when the cell is in a state of considerable chemical activity. When the cell divides they are shared between the daughter cells. On their first discovery they were thought to be as important in cell history as the nuclei, but for our purpose they are relatively unimportant. The one structure outside the nucleus which interests us somewhat is a tiny object, not always distinguishable, the centrosome, which, when the cell is about to divide, divides itself, passes round to opposite sides of the nucleus and sets the plane for nuclear division.

The cytoplasm has no obvious structure. It is a viscous fluid and over its surface there seems to be something elastic and semi-solid in the nature of a membrane. It has peculiar properties in that it is able to "distinguish" between substance which it will allow to pass into the cell and which it will keep out, and also what it will not allow to pass out. (Apologies are due for the use of such anthropocentric words as "distinguish", "allow", etc., of what, after all, can have no discrimination or will, particularly as modern biologists are inclined to believe that no hard and fast line between what is living and what is dead can be drawn.)

As we have said, it is the nucleus which chiefly interests us in the study of the hereditary transmission of the characteristics which determine personality. We were once one cell and one cell only—a fertilised ovum, the result of the union of a male cell with a virgin ovum or female cell. All our hereditary characteristics must have been carried in that one cell. In any one person we note that some characteristics are inherited from the father—e.g. the colour of the eyes, it may be, or the shape of the hands, the arching of the eyebrows, the shape of the ankles, the arch of the foot—whereas others are inherited from the mother. Therefore all the potentialities inherited from the father must have been carried in the tiny male cell, the spermatozoon, which he contributed to the fertilisation of the ovum. Similarly all the characteristics inherited from the mother—let us say the set of the hair or the shape of the ear, the poise of body and so forth—must have been carried in the virgin ovum

which she contributed, developed when fertilised, nourished and bore. (Note: "The embryo is, however, never any part of the mother, never at any time at all a part of the maternal life. . . .")[1]

Now the sperm cell consists practically of nucleus alone—there is hardly any cytoplasm. Moreover, experiments with enucleated sea-urchin eggs "fertilised" by sperm from a different species have given no certain indication of the influence of cytoplasm on inherited characters. Consequently we guess and indeed assume that all hereditary characters are carried by the nuclei of the uniting sperm and ovum. And as this assumption fits all the multitudinous experiments of the last forty years upon the mode of inheritance (see below), it is the assumption upon which we shall proceed.

Put briefly thus: the nuclei of the uniting sex cells carry the hereditary characteristics—it sounds a simple and comprehensible statement, but when its implications are considered, it is staggering. As staggering, in its way, as Newton's statement concerning the motions of the moon and the planets. It means that all the multiplicity of characteristics which make the difference between, say, Newton and Macchiavelli, Marcus Aurelius and Nero, Winston Churchill and Hitler—in so far as they were not distorted by environment and nurture—were carried in a speck of living matter perhaps not four twenty-five-millionths of a cubic inch in size. Such characteristics must have been rather thick on the ground, so that it would not be astonishing if, in the course of reproduction, some got elbowed out into limbo. That, indeed, may happen.

CHAPTER III

The Chromosome Ballet

It is best to begin the study of the transmission of characteristics by the nucleus with a description of normal cell division. We choose a body cell rather than a germ cell division because it is simpler and the plan is understandable from the first.

When a cell is about to divide into two daughter cells the state of unrest begins in the nucleus. Seen under dark ground illumination the resting nucleus appears, as we said above, almost structureless, but when the ferment of reproduction starts in it,

[1] Sherrington, *Man on his Nature*, p. 72.

a network appears which then resolves itself into threads or a tangled skein. The skein next breaks up into short lengths called chromosomes. They are in active movement and have been described by the late Dr. Strangeways, who specialised in tissue culture, as appearing like eels in a box. Each chromosome splits into halves longitudinally[1] and the halves migrate to opposite ends of the space where the nucleus originally was. Here they coalesce, each group forming a new nucleus, so that we have two where there was one before. As the two nuclei settle down

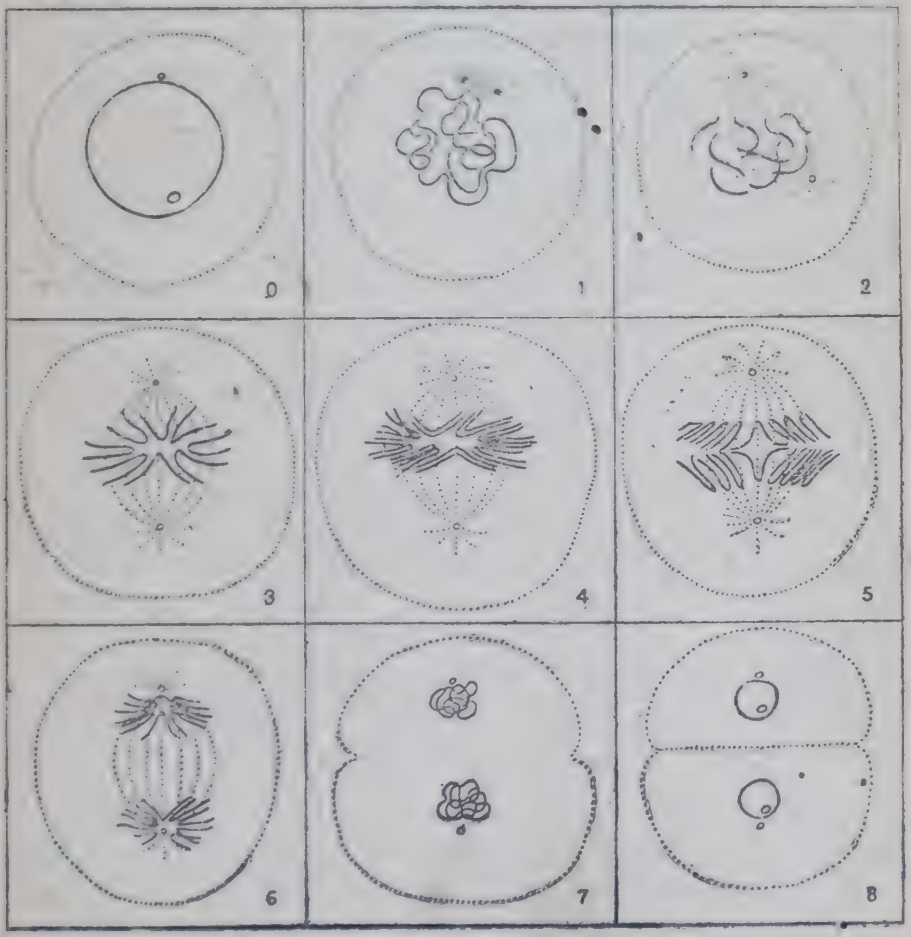


FIG. 2

The eight stages of mitosis: the formation of two daughter nuclei and cells from a mother cell. Note in 4 the splitting of each chromosome longitudinally into two, and in 5 the passage of the daughter chromosomes to opposite poles.

[1] Or is already split.

sumably one of each pair is from one parent and one from the other, though there are some interesting and important exceptions to this generalisation. As we shall see later, there is evidence that each chromosome carries a group of potentialities with it.

Further, each chromosome is not homogeneous. It is a thread with beads of stainable material on it. Of it may be a sheaf of threads as in the enormous chromosomes of the salivary glands of the fruit fly. Varicosities on these threads at regular intervals produce the effect of cross striation. There is apparently here in these swellings and cross striations material for carriage of unit characteristics, such as, let us imagine, blue-eyedness or six-fingeredness. But this is anticipating.

What are the sex cells? Are they simply portions of the big organism specialised for one purpose—reproduction—or are they distinct right from the first? Does the original fertilized ovum at its first division proceed to depute the formation of sex cells to one of the daughter cells and the formation of the body to the other? This was held to be something near the truth by doctrinaire biologists (there are such!) of the eighties of the last century in a struggle to discredit a belief in the inheritance of acquired characters. To-day it is believed that they are formed early in the course of the divisions which ultimately give rise to the fully formed animal. Though active and ripe sex cells may not be formed till much later—at the age of 14 in man—the tissues which makes them is laid down very early in fœtal life—which, of course, is not so very astonishing, for the sex cells are the only physically immortal things. All the rest of us is destined to mortality.[1]

If a fertilized ovum gives rise ultimately both to sex cells and to brain or liver or bone cells, and the characteristics are carried by the chromosomes, how is it that the sex cells, the brain, liver and bone cells are so unlike? The answer seems to be that only the germ cells contain *all* the chromatin, all the nuclear material obtained from the parents, but that the body cells lose a little here and there. They have lost a portion of their inheritance and can never return to the potentiality of forming a new individual—they have given up, like Esau, their birthright for a mess of soma.

Let us look at the division which produces the sex cells and reduces the number of chromosomes. It is best to follow it

[1] For a brilliant, convincing and humiliating statement of this fact, see Sherrington's *Man on his Nature*, pp. 144–5.

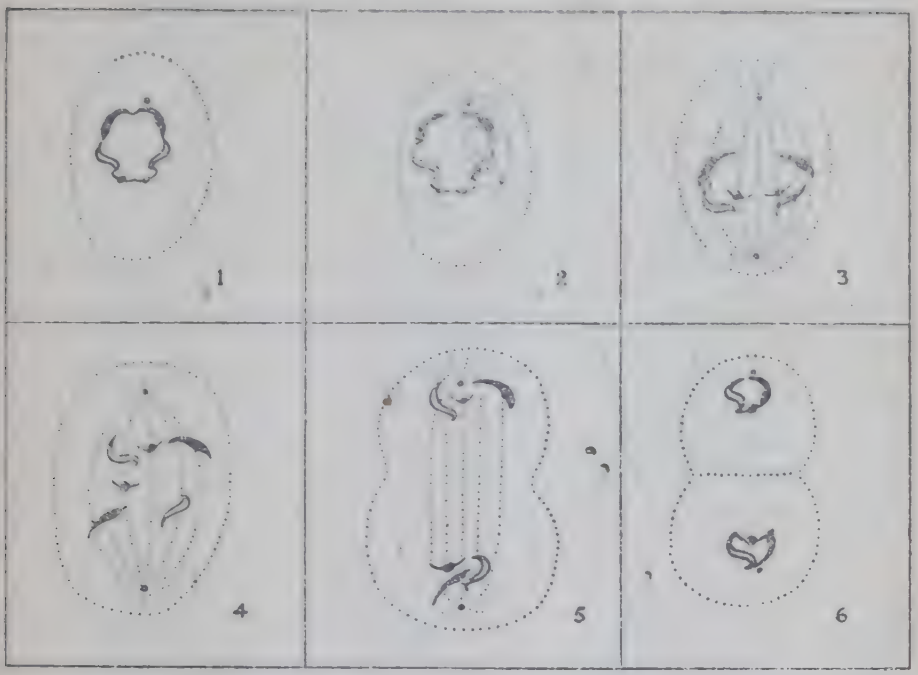


FIG. 3

Reduction of the number of chromosomes to half in the first division of spermatogonia in forming the sex cells. The diagrams are highly schematised and do not represent the state of affairs in any particular plant or animal.

1. Nucleus in the spirem stage showing three pairs of chromosomes
2. Breaking of the spirem into chromosomes.
3. Equatorial arrangement of the three pairs.
4. Migration of one of each pair towards the poles.
5. Assembly at the poles.
6. Constitution of two daughter nuclei from half the number of chromosomes in mother cell.

with diagrams in which we will assume that the pairs of chromosomes are few in number and identifiable.[1] The process appears simple. There is no splitting of the chromosomes longitudinally at the equatorial (monaster) stage of mitosis. Consequently there go into the construction of the daughter

[1] This account, in fashion when the writer was a student, is no longer held to be true. In an early stage of the creation of sex cells "four-stranded" chromosomes are formed, and the subsequent standard divisions into four daughter cells sort these four strands among the sex cells.

nuclei only half of the number of chromosomes in the original cell, *i.e.* half the number of chromosomes in a body cell. In Fig. 3 this is illustrated in diagrammatic form. The nucleus of the parent cell is supposed to derive from three pairs of chromosomes which can be easily distinguished. They appear when the spirem breaks up. They attrange themselves equatorially to the spindle. One of each pair migrates to one pole and one to the other without the longitudinal splitting seen in body-cell division. Thus in our figure, three chromosomes migrate "north" and three "south". When the daughter nuclei are constituted they consist of the chromatin material of three chromosomes only instead of six. In the diagram let us assume that the chromosomes to the "east" are from the male parent and those to the "west" from the female. It does not follow that all those in the eastward position migrate to the north and all those

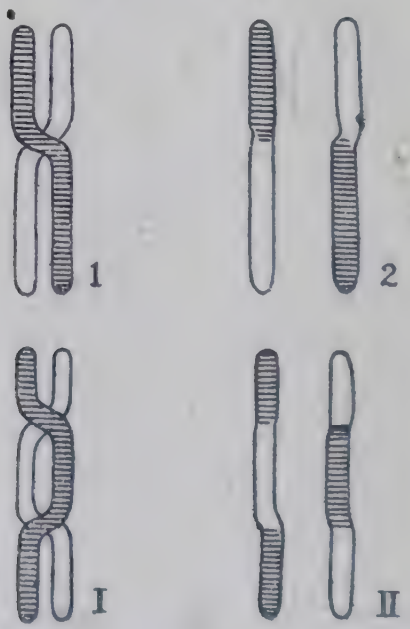


FIG. 4

Two possibilities of interchange of substance between pairs of chromosomes in the division preceding the reduction division. The shaded chromosome is supposed to be from one parent and the unshaded from the other. From the twisting *might* arise two *unlike* chromosome of mixed parental stock--"hybrid" chromosomes. Such possibilities can be used to explain unexpected and anomalous facts of inheritance.

in the westward migrate to the south. Chance seems to determine which goes where. In the daughter nuclei all the chromosomes derived from the male parent *might* reassemble in one nucleus, but the chances are against it. If "potentialities" are carried by the chromosomes the daughter cells will usually carry "potentialities" inherited from both parents. They will not "favour" either parent completely.

In the divisions producing sex cells a definite plan is followed. The cell which is to produce these cells divides once—and at this stage the halving of the number of chromosomes occurs—and then each daughter cell divides again. But here an odd thing occurs. Whereas each of the four cells which can become a mature male sex cell really does so, only one of the four potential female cells develops into an egg cell or ovum. The others perish and a considerable amount of nuclear material is thus jettisoned. The implication of this is not clear.

The story as told above has been over simplified. Just before the division in which the reduction of the chromosomes takes place the chromosomes of the cell behave in a peculiar manner. They are, of course, in pairs. These pairs come together; they seem to conjugate or, at any rate, to exchange matter one with the other. They sometimes twist over each other, and this twisting around each other may result in the interchange of material between the paired chromosomes (see Fig. 4). This interchange is important in explaining some apparently unusual results of inheritance.

Another unusual division before the first division in the production of mature sex cells is one in which the pairs of chromosomes join end to end, forming a circle or loop. One half of the loop migrates "north" and the other "south", and so "maternal" chromosomes congregate in one daughter nucleus and "paternal" chromosomes in the other. Halving of the number of chromosomes would result if the chromosomes did not double (as they do) during their migration.

To sum up the facts relevant to our discussion of the physical basis of personality we can say—

(i) The probable carriers of hereditary potentialities are the chromosomes.

(ii) The sex cells have half the number of chromosomes of the body cells and the body cells have pairs of chromosomes, one of each pair being contributed by one parent and one by the other.

(iii) It is in the formation of sex cells that the halving of the number of chromosomes is achieved.

(iv) The distribution of the chromosomes between the sex cells, if we consider their origin, is a chance distribution.

(v) There are means by which interchange of material or whole segments of chromosomes between pairs can and probably does take place, so that a chromosome "dealt out" to a sex cell is not wholly from one parent or the other.

(vi) Finally chromosomes are often identifiable by shape and can be traced from generation to generation.

CHAPTER IV

The Determination of Sex

If we can show that sex is due to chromosome "make up" we have gone a long way to show that personality is determined by heredity. For no one would deny that sex determines personality.

What the difference in personality between man and woman is hardly concerns us. Very few people doubt that there is a difference; in fact, it is an age-old discussion, often conducted with some acrimony and inevitable injustice. Women say "Just like a man" and men say "Just like a woman" to explain some exasperating trait of character or happening. This surely is evidence—though of course not scientific evidence—that the theory is widely held that man and woman have different types of personalities.

But we must beware of two things. (i) It is distinctly conceivable that social conditions have developed these dispositions which we imagine to be fixed by inheritance, and (ii) it is dangerous to generalise from inadequate knowledge, recognising that no man knows intimately the character of more than a few women—his mother and his wife or wives, and no woman knows intimately the character of more than a few men—her father and her husband or husbands. Casanovas and Don Juans, and Messalinas and Catherines we may leave out of account, for their relations with the opposite sex, though extensive, were peculiar.

(i) That social conditions determine personality may be suspected from the following. In our present-day society women

may seem obsessed by clothes and few men are. It seems natural that women should concern themselves with their adornment. The male who does so is an object of contempt. But in matriarchal tribes we are told that the young men behave exactly like the women in our society and that the women heads of tribes complain bitterly of the frivolity of the young men. Perhaps the differences in characters between men and women descried by amateur ethnologists and psychologists are the result of circumstance and not of physical differences.

(ii) Generalisation on insufficient basis is a besetting sin of the human race which may some day be overcome by a truly scientific education. Meanwhile we may tentatively accept the generalisations of those who meet large numbers of both sexes in a professional way—such as priests, doctors and psychologists. A few such generalisations are here collected:

(*a*) A priest. In every man there is something of a pig and in every woman something of a cat.

(*b*) A physician. A woman is more self-centred than a man. She is the most important thing in her life. Next comes her eldest son and then perhaps her husband.

(*c*) A psychologist. It is peculiarly distasteful to a man to have to work on problems of human relationship . . . for the woman the task is not so difficult. She meets her greatest inertia when the need is to become conscious . . . of accurate definition—not when dealing with relations.[1]

We may add to these generalisations one from a novelist and two from an Oxford don. H. G. Wells writes that "Men are slower and stupider; women quicker and sillier"; C. S. Lewis, that women are more talkative when tired and men more silent; and that unselfishness to a woman means work for other people, but to a man not giving other people trouble.

Speaking as a life-long feminist, as a married man of twenty years' standing and as a teacher in a women's college, the author gives it as his belief that there certainly is a marked difference between the personalities of men on the one hand and women on the other. Women have a distinct aptitude for detail and long-range planning; the male is bored with detail and prefers broad outlines; women, as is natural, are interested in homes, men in causes; there is little sodality among women and much among men.

[1] M. Esther Harding, *The Way of All Women*, p. 301, Longmans Green & Co.

All these generalisations seem to fit in with the biological, or rather the main biological function of woman, so there appears to be some justification for them. But justification or not, it hardly matters so long as there is a general agreement, which I think is undoubted, that sex conditions personality. Sex is, as we shall show, definitely determined by the nature of the chromosomes dealt out to the sex cells.

The proof is almost as definite as it could be. Right through the animal kingdom the sex of the animal is determined by the chromosome make-up of the fertilised ovum. There may be variations, slight variations, in the exact plan followed, but so far as has been investigated—and this includes sea-urchins, nematode, worms, grasshoppers, flies, moths, butterflies, beetles, bees, wasps, spiders, and mammals including man—it is the chromosomes which determine sex.

Above, the impression may have been gained, though warning notes were uttered, that the chromosomes are paired and alike. This is not quite true. Sometimes there is an unpaired chromosome. The rule that the body cells have an even number of chromosomes is true in some species only for the male and in others only for the female. One chromosome is missing. In the grasshopper, for instance, the male has 31 chromosomes and the female 32. And sometimes, though the total number of chromosomes is even, one of a pair of chromosomes is unlike its partner. It may be bent while the other one is straight, or it may be smaller than the other. This last is true of man. In the body cells of a man there is one chromosome markedly smaller than its partner; in woman the chromosomes which determine sex are alike.

Before going further it will be best to see by diagram what must happen when sex cells are formed from cells having the normal complement of chromosomes, i.e. when reduction division takes place. We could choose man to illustrate this, but the fruit fly is simpler because it has but few chromosomes altogether and the sex determining chromosomes are markedly different. In the female there are two straight chromosomes and in the male one straight and one hooked (see Fig. 5). When the divisions which halve the number of chromosomes take place we have the result shown in Fig. 5, 2. The ova (a and b) all have identical make-up, but the sperm cells are of two types: one with a straight sex chromosome and one with a hooked chromosome (c and d, Fig. 5, 2). There are four possible

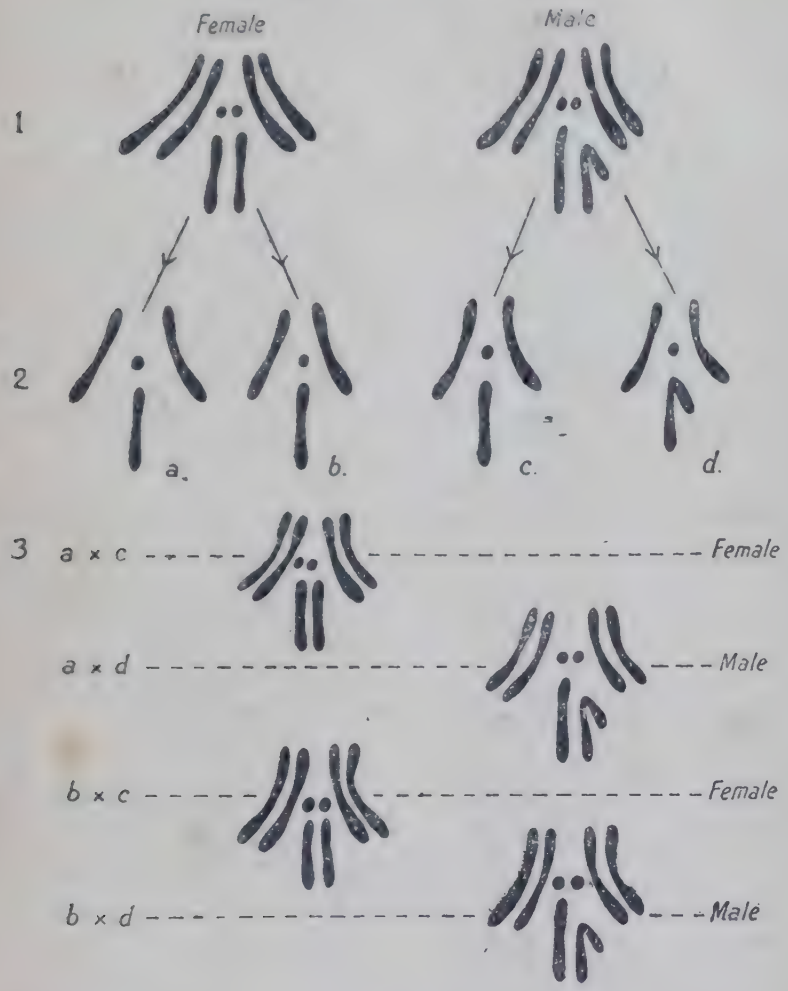


FIG. 5

Highly schematised diagrams of chromosomes in the fruit fly.
1. Chromosomes in the body cells of female and male fruit fly respectively.
2. *a* and *b*, chromosomes in the mother ova; and *c* and *d*, sperm cells.
3. Possible unions between ova and sperms resulting in offspring, 50 per cent. of which are female and 50 per cent. male.

matings, a × c, a × d, b × c, b × d, as shown in the figure. It will be seen that a × c and b × c produce females and a × d and b × d produce males. Therefore the offspring of fruit flies (apart from other complicating circumstances) should be 50 per cent. females and 50 per cent. males, as indeed they are.

In the grasshopper, as we said above, one is missing in the

male, so if we called the extra chromosome the X chromosome, then the female make-up is XX and the male XO. In moths it is the other way round. XO determines femaleness and XX maleness. Where there are two chromosomes connected with sex, as in the fruit fly, we can call the large normal-shaped one the X chromosome and the hooked one Y. Females are XX and males XY.

Man follows the XY plan. Of the sex chromosomes in man one is large and one small. If a fertilised ovum possesses two XX then that ovum will develop into a girl, if XY a boy will result. Unfertilised ova are all alike. They contain one X each. The spermatozoa are of two types produced in equal numbers—one with an X chromosome, one with a Y chromosome. As there are approximately equal chances of X chromosome sperms meeting X chromosome ova as of Y sperms meeting X ova there ought to be as many girls born as boys, and that is approximately true.

It is moreover a fact that the spermatozoa in man and many mammals can be seen to be of two sizes in equal numbers: one larger and one smaller. It is almost certain that the large sperms carry the X chromosome and the smaller the Y chromosome, so that if we could separate the two (by centrifugation or by making them run an obstacle race) we could make practically certain of having a heifer, a ewe, or a girl at will. Doubtless experiments are being made to do this—probably in the U.S.A. and the U.S.S.R.—for it would prove advantageous in agriculture, though possibly not quite so advantageous in human affairs.

It is only approximately true that equal numbers of boys and girls are born. As is well known, there are about 105 boys born to 100 girls, and this ratio is greater still in favour of maleness if stillbirths and abortions are taken into account. It appears that more of the small spermatozoa succeed in fertilizing ova than the large. They get there first, possibly because of their smaller size and greater agility, or they penetrate the ovum more easily. Anyhow, the sex ratio is not 100 : 100 as it should be on a theory of complete chance selection, but it is near enough to show that chance is the main factor.

There are few considerations of less importance. Why does the sex ratio decrease from fertilization to birth and from birth to old age? There are more boy babies conceived than girls, not quite so many more boys than girls born, and by the time

old age is reached there are more women than men. So far as gestation is concerned boys are less "viable" than girls. They are more difficult to rear than girls. They stay the course of life less well than women. Why should the possession of a dwarf chromosome render one less able to withstand the arrows of fortune? Why should two X chromosomes enable one to outlive the person with but one? Doubtless someone will dub the X chromosome the "will to live" chromosome or postulate a semilethal "gene" on the Y chromosome, but these are speculations only and really nothing more than descriptions in unproved terms of facts.

Finally, those whom it may please may play with the idea that woman is pure in her chromosome make-up and man impure. Or, if you like, half a woman. It reminds us of Chesterton's epigram, "Men are men, but man is a woman." This could be read, "Women are women, but man is half woman" from the point of view of chromosomes. But this is merely intellectual frivolity of no importance.

CHAPTER V

Mendelian Inheritance

"A vast similitude interlocks all" was quoted from Walt Whitman early in this book. Some of us no longer feel staggered to think that galaxies, millions of light years away from us, are built and run on the same plan as the atoms which compose the dust beneath our feet and the matter of our brains, but when we find that the same laws of inheritance are discoverable in plant, animal and man we marvel! A vast similitude interlocks all inheritance; whether of eye colour in man, the coat colour in cattle, cats and rats, colour in sweet peas, antirrhinums and irises, and the roundness or wrinkledness of culinary peas. Doubtless the "cunning fakir" can interpret this and tell us that it is all "nothing but ——" That, however, does not concern us, but it means, none the less, that, for the purpose of this book, a nodding acquaintance with the simpler discoveries of Mendelism is essential. So in this and the next chapter we will struggle with Mendelian inheritance.

To anyone who has dipped into the facts of hybridisation, first discovered by the Abbé Mendel and rediscovered about the

turn of the century, the facts related in the last chapter will have a familiar ring. The 50 : 50 ratio appears in Mendelian inheritance when the one parent is a hybrid and the other is a pure "recessive". For example, if we cross an albino rat with a piebald rat, which itself is the offspring of an albino and a piebald, 50 per cent. of the offspring will be albino and 50 per cent. piebald.[1] If we cross a plicata iris with a self-coloured iris itself the offspring of a plicata crossed with a self-colour, the results are 50 per cent. plicata and 50 per cent. self. The same separation out into a 50 : 50 ratio would occur if a smooth-haired bitch/dog mated with a dog/bitch, the offspring of a cross between smooth-haired and wire-haired animals. The 50 : 50 ratio appears where one parent is a hybrid and the other is pure as regards a character which slips into the background when it meets a stronger character such as piebaldness in rats, self-colour in irises, or wire-hair in dogs. Be it noted, however, these characters (piebaldness, etc.) have no linkage with sex. We can make the crosses either way round (piebald buck to white doe or white buck to piebald doe) and the results will be the same. (Later we shall meet characters which are linked with sex.)

Such a type of inheritance is met in man, for example, in the inheritance of eye colour. If we count all eyes from hazel to

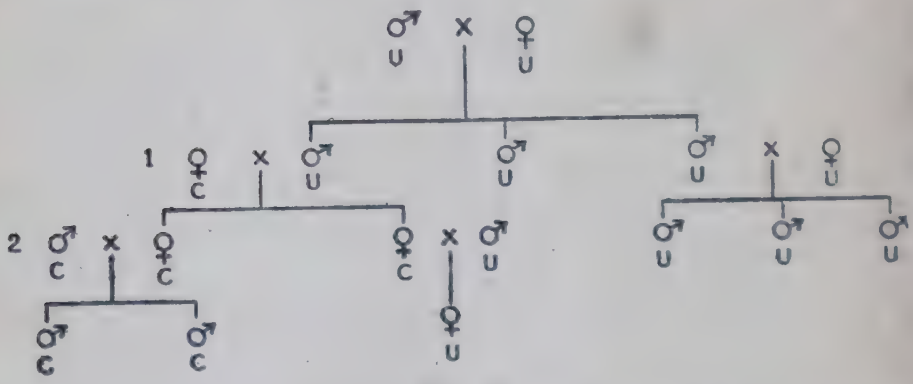


FIG. 6

Inheritance of eye colour. A four-generation pedigree consistent with the belief that blue or grey eyes on the one hand and hazel or brown eyes on the other are inherited according to rules of Mendelian inheritance. C = hazel or brown eyes. U = grey or blue eyes.

[1] Of course we must repeat the experiment many times for the ratio to come out approximately 50 : 50. One such mating, even when resulting in a large litter, would not give the exact 50 : 50 ratio.

brown as "coloured"[1] and blue eyes as "uncoloured" we meet the same ratio, if blue-eyed people mate with coloured-eyed people one of whose parents had uncoloured eyes. Thus if a brown-eyed man marries a woman with blue eyes and some of their children have blue eyes, you may be sure that (apart from unchastity of the woman) one of his ancestors had blue eyes. If the offspring of many similar marriages be examined it will be found that approximately half the children have coloured eyes and half uncoloured. Here is a family tree inheritance of eye colour (Fig, 6).

It will be seen that in the two marriages between people with blue or grey eyes no offspring with dark eyes appeared. In the three other marriages the only one in which uncoloured eyes appear is the one in which the parent showing "colour" had only one dose of colour and not two. Presumably the parents numbered 1 and 2 in the family tree had a dose of colour from each parent.

Let us reduce all these to something like a formula:

Body cells have—

2 X chromosomes in the female and X and Y chromosomes in the male.

2 A(lbino) characters in the albino and A and P(iebald) characters in the hybrid piebald rat.

2 Pl(icata) characters in the plicata iris and Pl and S(elf) characters in the hybrid self iris.

2 U(ncoloured) characters in the blue eyed and U and C(oloured) in the hybrid-coloured eyed.

In the sex cells the ova have one X in each ovum and the spermatozoa have either X or Y.

The results of chance union between ovum and spermatozoa are XX, XX, XY, XY, or a ratio of 50 : 50.

Similarly, if we assume that the albino character attaches to a chromosome and piebaldness to its pair, these separate from each other in the sex cells of a hybrid.

Thus the body cells of the albino rat can be represented by A, A. and those of the hybrid piebald rat can be represented by A. P.

On the formation of sex cells these separate: A, A, A and P.

The sex cells of the albino carry one dose of A each, and of the hybrid piebald one will carry A and another P.

[1] Blue eyes have no pigment at or near the front surface of the iris of the eye.

The results of chance union between ova and spermatozoa are AA and AP; AA and AP; 50 : 50 ratio, just as with sex.

Similarly, we can say that the body cells of the blue-eyed are UU and those of the hybrid-coloured eyed are CU.

Their sex cells are respectively U and U; U and C.

The possible combinations are UU. UC. UU and UC, or 50 per cent. blue eyed and 50 per cent. coloured.

And we could go on and multiply, perhaps a hundredfold, characters which are inherited in this way.

From all this argumentation spring two astonishing things: (i) a single plan of inheritance is followed in many living organisms, whether plants, animals or man—"a vast similitude interlocks all"—and (ii) the characters inherited are attached to the chromosomes.

These are the two main discoveries in inheritance of this century. It is true that the work on inheritance was started in the sixties of last century and on the chromosomes in the eighties, but the main volume of work has been accomplished in this century and inheritance and chromosomes linked together. The work has been international, and we mention de Vries in Holland, Bateson in England and Morgan in the United States of America. Probably the work of the last mentioned has had the greatest effect in establishing the modern views of the biologist on inheritance. We cannot do more than touch the fringes of the subject, and it is probably best to start with some of Gregor Mendel's experiments, although they may seem to have at first sight but little to do with human inheritance.

If Mendel crossed pure strain green culinary peas with a pure strain yellow peas the offspring were all yellow. These yellow were all hybrids, they had one dose of yellowness and one dose of greenness, but the yellowness got the upper hand. If these hybrid yellow-greens were indiscriminately crossed or inbred (peas self-fertilise) the offspring separate out as three yellows to one green. The green acts as a pure strain. Of the three yellows, one appears to be a pure strain and two are hybrid yellow-greens. If the hybrids are allowed to cross again the new generation will be in the ratio three yellows (i.e. one pure yellow and two hybrid yellow) to one green. And so on, by hybrid inbreeding, for generation after generation. The oddity of this is in the arisal from a hybrid of a pure strain. This seems against all logic and common sense, and needs explanation.

Mendel worked with seven different characteristics of culinary

peas, such as tallness and shortness, roundness and wrinkledness, colour or whiteness of flowers, and found that similar rules were followed. It has been found that the same rules apply to a thousand and one characters in plants, animals and man, of which two examples must suffice.

Take a pure piebald strain of rat and mate with an albino. (Repeat, say, twenty times or more.) All the offspring are piebald in the first generation. Inbreed this first generation indiscriminately. Three-quarters of the second generation are piebalds and one-quarter albinos. Of the piebalds one-third are pure piebalds (i.e. they breed true) and the other two-thirds are hybrids. Inbreed these hybrids, and again in the third generation we get the 3 : 1 ratio; three piebalds to one albino. In fact it works just like the peas.

In man it is undoubted that the same rule of inheritance applies to eye colour. Pure brown-eyed stock mated with blue-eyed stock produces in the first generation all brown (coloured) eyes, which are of course hybrids. If hybrid-coloured eyed people marry the chances are that their offspring will be three-coloured eyed to one uncoloured (blue) eyed. Of the brown eyed, one-third will be pure brown—i.e. having a double dose of brown—and the other two-thirds will be hybrids, with one dose only. And there are dozens of characters in man which seem to behave in the same way. Many of them, alas, are diseases; some, "inborn errors of metabolism". Thus lack of the power to consume cystine or tyrosine (two products of protein digestion) seems to be inherited in a Mendelian fashion.

Naturally Mendel tried to sum up the facts which he discovered in a hypothesis, and his hypothesis was this: that the sex cells (the gametes) can carry one only of these pairs of characters which are mutually exclusive. In his examples it was the tallness or shortness of the peas, or the yellow or green appearance of the seeds, etc. We can extend this to-day to dozens of characters, such as coloured eyes and light grey and blue eyes. In man the ovum can carry either dark eye colour or light eye colour—never both—and the same is true of the spermatozoa. Another way of expressing it is to say that the gametes are pure strain and never hybrids. Hybridism shows itself only in the body cells. For a pair of characters they can be heterozygous, which means that they carry both, say dark-eyedness and light-eyedness. If they carry two doses of dark-eyedness or light-eyedness we call them homozygous for whichever character they

carry. We naturally think of the chromosomes in explaining this type of inheritance. Just as one gamete cannot carry more than one of a pair of characters so, too, the gamete cannot carry more than one of a pair of chromosomes found in the body cells of the parents. Mendelian characters sort themselves just as the chromosomes do!

Now this at first was not recognised. Mendel could not of course relate the "purity of the gametes" to the halving of the number of the chromosomes in the production of gametes, for chromosomes had not been discovered. Moreover, de Vries and Bateson did not so relate them. That was left for Morgan. And it is interesting to read from his letters how Bateson was converted to the idea of the importance of the chromosomes in carrying the Mendelian characters by a visit to Morgan's laboratory in New York. Now it is considered to be no longer a hypothesis but a fact.

Before going further it would be as well to show by a little formulation of the theory how we can predict what will happen in crossing two plants or animals which differ in one only of a pair of characters: e.g. colour and albinism. Let us call colour C and albinism A, and let us assume that the male is coloured. There is only one possible type of union, as shown in the square below—an A must unite with a C.

		Male gametes C	C
Female gametes	A	AC	AC
	A	AC	AC

The result is AC. As colour masks albinism, all the offspring will be coloured. But suppose now our offspring of this first generation interbreed at random. Then the square becomes:

		Male gametes A	C
Female gametes	A	AA	AC
	C	AC	CC

and the results are 25 per cent. pure AA (or albino), 50 per cent. AC (coloured with one dose of colour), and 25 per cent. with

two doses. As it makes little difference to *outward* appearance whether there is one dose of colour or two, we get the Mendelian ratio 1 albino : 3 piebalds.

Suppose again albinos are mated with piebald animals containing only one dose, the square is now:

		Male gametes A	Male gametes C
Female gametes	A	AA	AC
	A	AA	AC

In other words the result is half the number albinos to half the number coloured—the 50 : 50 ratio we met earlier in the determination of sex. Let us put the sex facts out in a square. The ova carry X and X; the spermatozoa X or Y:

		Male gametes X	Male gametes Y
Female gametes	X	XX	XY
	X	XX	XY

Now an animal, such as man, carrying XX is female and one carrying XY is male, so again we obtain the 50 : 50 ratio.

From such considerations we can jump straight to the inadvisability of first-cousin marriage unless you can be certain of no hidden strain of undesirable character, such as albinism. Human albinos occur and are at great disadvantage. They often are the result of first cousin marriages, though by no means necessarily so. If two people each having the make-up AC marry, then the chances are that one out of four offspring will be albino. No one can be sure that he is CC and not AC. Outwardly there is nothing to show that one is heterozygous. Undesirable characters are more likely to meet in cousin marriages than in random mating.

The Mendelian square can be used to predict what will happen when hybridising plants or animals with two pairs of characters. It does not matter whether we take plants or animals—the rules are the same. We will take yellowness and greenness, roundness and wrinkledness in culinary peas. As we know already, yellow-

as a mnemonic,[1] but is not true of black and white marriage. Moreover the offspring of a tall man and a short woman usually show heights intermediate between the two, and there seem always to be infinite gradations between one extreme in human beings and the other. Inheritance ought to appear "stepped" or "particulate" in man, whereas it appears smoothly graded without sudden changes of direction. At first sight it does not do so except in such a thing as eye colour and sex.

Part of the trouble was due to Mendel's characteristics being labelled (quite reasonably) "dominant" and "recessive". Yellowness in pea seeds is "dominant" to—i.e. it masks—greenness. Blue eyes are "recessive" to dark eyes. Sometimes, however, the characters blend when mixed. "Blue" Andalusian chicks are the offspring of black and white parents. Combs in fowls blend to give a new "appearance" or phenotype. Again, there are not always pairs of mutually exclusive characters or "alleles" as they are called. In the eye colour of the fruit fly, for example, there are no less than 14 alleles for eye colour crossed with "white

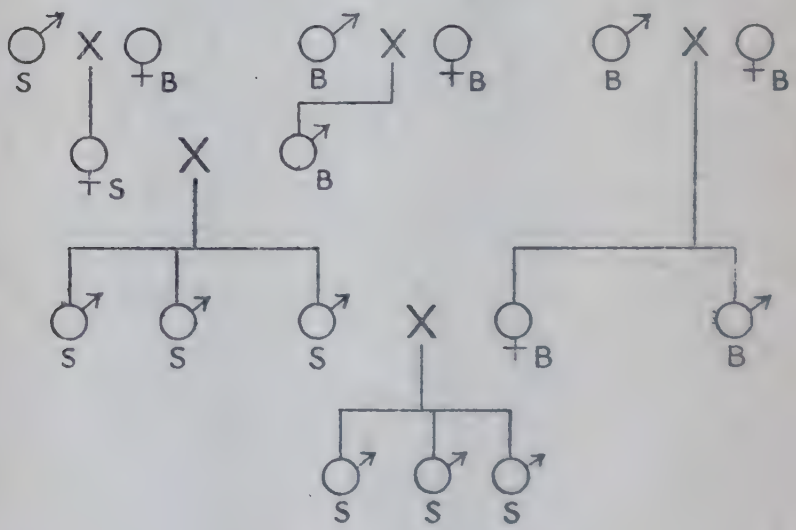


FIG 7

Genealogy showing baldness (or scanty hair) and hirsuteness more compatible with hirsuteness being dominant to baldness than the other way round as generally supposed. S = good hair. B = scanty hair or baldness.

[1] It is very bad Mendelism, for the segregation is made to take place in the first generation, whereas it would occur in the second generation if it occurred at all, which it would not.

eye". And in human blood grouping the facts are explained by assuming three alleles. There are numbers of independent genes which between them determine weight.

Much of the rest of the trouble was due to over-hasty generalisation. Baldness, for example, was supposed to be dominant to hairiness and to be sex-linked with masculinity. Anyone with a political axe to grind and a modicum of biological knowledge invoked Mendelism to support the nostrums he advocated. Fortunately the serious worker was not deterred, and to-day the majority of biologists believe that Mendelian inheritance plus a knowledge of the behaviour of chromosomes can explain the facts of heredity. They postulate that each hereditary potentiality is carried by a gene which "may, with some licence, be styled a quantum of heredity,"[1] and that these genes are dealt out to the gametes in an entirely Mendelian way, so that our physical make-up is determined by our gene make-up. "Each gene in the egg-cell embodies a 'unit character' in the make-up of the individual springing from the ovum."[2]

Further, the chromosomes are the carriers of these genes. We believe this because

(i) The chromosomes and genes behave as individual units.

(ii) The facts of inheritance can be explained by assuming pairs of "alleles", one member of each pair being supplied by one parent and one by the other. The same is true of chromosomes.

(iii) Chromosomes and these alleles behave in the same way when the gametes are formed.

(iv) The chromosomes are dealt out independently of each other in cell division. So are the alleles and the genes carrying the allelomorphic characters.

The later developments of the view that the chromosomes are the carriers of the genes is that the chromosomes contain a string of genes each with its definite position in the chain, and much has been done in the mapping of the position of the genes in animals such as the fruit fly and the pig and in such plants as the maize. The mapping of the human chromosome has naturally not gone very far, but doubtless it will be achieved in time. Some small progress has been made, and we know something of the position of the gene responsible for normal colour vision and the normal clotting of blood. These must be carried

[1] Sherrington, *Man on his Nature*, p. 118.
[2] *ibid*, p. 119.

on the sex chromosomes, for both these characters are sex-linked. The ordinary colour blindness which has to do with vision of red and green is very rare in women, is present in about 4 per cent. of men, and is handed on via the woman who may not show colour-blindness herself.

Similarly, inability of the blood to clot shows itself in males, never in females, but is handed on always by the woman. In both cases—colour blindness and hæmophilia (the name given to lack of power of blood to clot)—the gene must be attached to the X chromosome.

CHAPTER VI

Mapping the Chromosomes

As said immediately above, the gene (or perhaps absence of a gene) which determines colour-blindness must be related to the X chromosome. If it were related to the Y chromosomes all the sons of a colour-blind man would be colour-blind.

Let us suppose that by accident one X chromosome in a woman lost its colour vision gene. We could represent that woman as X^cX^c (where X^c represents normal vision and X^c represents colour-blindness). Such a person would not be colour-blind, but might be labelled "heterozygous" for colour vision.

Marriage with a normal man would result in the following possibilities:

	X^c	Y
X^c	X^cX^c normal daughter	X^cY normal son
X^c	X^cX^c heterozygous daughter	X^cY colour-blind son

or one daughter who could not hand on colour-blindness, one who could, one normal son and one colour-blind son.

If a colour-blind man marries a completely normal (homo-

zygous) woman all the offspring would be normal for colour vision, though any daughter arising from the marriage could hand on colour vision defect. The sons would not be colour-blind, nor could they possibly hand on the defect.

	X^c	Y
X^C	X^CX^c	X^CY
X^C	X^CX^c	X^CY

As we said, colour-blind women are extraordinarily rare, but they do exist. They would have to have two X^c chromosomes, and they can arise from the marriage of a colour-blind man with a carrier (heterozygous) woman. Thus:

	X^c	Y
X^C	X^CX^c carrier daughter	X^CY normal son
X^c	X^cX^c colour-blind daughter	X^cY colour-blind son

In such a marriage a colour-blind daughter, a carrier daughter, a colour-blind son and a normal son might arise.

Similarly the results of marriage of a colour-blind woman with a normal man, or of a colour-blind woman with a colour-blind man can be prognosticated. In the former all daughters would be carriers and all sons colour-blind; in the second all sons and daughters would be colour-blind.

Prognostications such as the above have naturally not been verified by experiment, but so far as the collection of pedigrees has proceeded they fit the facts, so that we may reasonably assume that the colour vision gene is attached to the X chromosome.

Now colour-blindness is not a very great handicap unless the colour-blind person wants to go into the Navy, the Merchant Navy, or to become an engine driver, though it must be a handicap to the medical student, the tailor, the dressmaker and

milliner and the oil and colour man. It is difficult to be an artist if colour-blind, though Eugene Carrière surmounted the difficulty, and it must cramp the poet. Again it must have caused the Quaker chemist Dalton some distress of mind to find that, instead of a pair of black silk stockings, he had bought his wife a pair of scarlet ones. The point is that even so small and inconsiderable a defect as colour-blindness must affect one's personality, and as colour-blindness is inheritable and plausibly connected with a defective chromosome we see that one's physical make-up determines personality.

A much more ghastly sex-linked character is that of hæmophilia. When shed, blood should clot, for the clot plugs the severed blood vessels and prevents the person's bleeding to death. The body has a whole battery of ferments, activators, etc., to bring about blood clotting when blood is extravasated. It is true that in the absence of a particular vitamin the blood loses its power to clot, but this is a factor of "nurture", not of "nature". People are born with the lack of the power of blood to clot, and no "nurture" will put this right as yet. Fortunately the state is rare and not likely to increase because it is a semi-lethal characteristic. The person possessing this lamentable character is likely to die before he founds a family.

The Royal families of Europe have been plagued with this trouble. (The late Tsarevich of Russia was an example.) It appeared in the Spanish Royal family and elsewhere. If I have not misinterpreted him, J. B. S. Haldane believes that the trouble arose from Queen Victoria who married off so many of her descendants into the Royal families of Europe. If so, she must have spontaneously become a carrier of hæmophilia by mismanagement of her genes.

Let us suppose that a gene for blood-clotting is absent from one of the X chromosomes and represent this as X^1.

Then XX^1 would represent a female carrier and X^1Y a male with hæmophilia.

If a normal male XY marries an XX^1 female the possible offspring are one normal female XX, one carrier female XX^1, one "bleeder" male X^1Y and one normal male XY.

If a bleeder male X^1Y manages to survive to adult age and marries a normal female XX, all the possible male offspring are normal and cannot hand on the complaint, whereas all possible female offspring are carriers and will hand it on to some of their sons.

It would be possible to obtain a female in which both X chromosomes were deficient by marriage of a carrier woman with a hæmophiliac male, but such a child, if she survived so far, would bleed to death on reaching puberty.

A problem that arises at once from the determination of sex by chromosomes is how we can explain a whole range of phenomena in which there seem to be intergrades in sex. They may be morphological or psychological. Among animals sometimes a whole side of an animal takes on the secondary characters of sex. One half of a pheasant may appear male and the other half female, or there may be a mosaic pattern: patches of a butterfly or moth may have the distinctive male colouring, whereas the rest of the animal may appear female. Such states may be explained by the accidental dropping of a chromosome at nuclear division. Supposing at the first division of the fertilized ovum a chromosome is misplaced, then one half of the animal arising from such an ovum will be male and the other half female. If the loss occurs at a later stage, then all the cells arising from the cell where the loss has occurred will be of one sex in appearance and the rest of the body of the opposite sex appearance.

One queer result of experiment with hatching frogs' spawn appears at first sight to throw grave doubt on the whole theory of sex determination by chromosomes. Normally hatched frogs' eggs give the usual 50 : 50 ratio of sexes. But if the eggs are kept at a high temperature, or if they are retained in the body of the female longer than is normal the eggs when hatched show a preponderance of males. We may even obtain hatches in which 100 per cent. are males. This surely suggests that the chromosome theory of sex determination is false as applied to frogs. Some of these males must have the XX make-up and not the XY. Yet they function as males.

None the less this apparent exception can be used to *prove* the rule, for when these males with an XX make-up are mated with normal females the offspring are 100 per cent. females, proving that the males really had an XX make-up. In other words the chromosomes really are immutable, but their expression was thrown awry by other factors. The high temperature or the staling of the eggs before fertilization so interferes with the activity of the chromosomes that they cannot "make themselves felt". They were there all the time and, given their chance, behave in a normal manner.

There seems to be a war between the sex chromosomes and the rest (the autosomes), and if the balance between the two is upset the sex displayed by the adult animal is not what might be expected. In the fruit fly the sex is determined by the proportion of the X chromosomes to the autosomes. If the balance is 1 : 1 the adult animal is female, if 1 : 2 it is male. Should, by accident, the numbers of the sex chromosomes and the sets of autosomes be doubled or trebled—say 3 sex chromosomes to 3 sets of autosomes—then the resulting animal is female; if the proportion is 1 : 2—say 2 sex chromosomes to 4 autosomes, it is male; if, however, we get 2 sex chromosomes to 3 sets of autosomes the result is an animal somewhere in between male and female—an intersexual animal. Sometimes the autosomes appear to be slow in their action, and, as shown by Goldschmidt when the Japanese gypsy moth is crossed with the Emperor, an animal which starts apparently female reverses its sex and becomes male.

Physical intersexes appear not only in birds and fruit flies and moths, but among mammals including human beings. In fact intersex pigs are a positive commercial commodity in the New Hebrides, commanding, as they do, a high price for use in religious ritual. Some, but not all, of these phenomena can be explained either by loss of sex chromosomes at some stage of development or by an upset of balance between autosomes and sex chromosomes.

It would be straying too far from our subject to consider these phenomena further. We must be content merely to say that the apparent exceptions to the broad rules of Mendelian inheritance can be explained by sex-linkage of characters; by accidents in the complicated dance of mitosis; by the linkage of characters in chromosomes; by the crossovers between chromosomes at the synaptic or at a later stage (see p. 24) and by mutations. These very exceptions have enabled the geneticists to map the chromosomes in such an animal as the fruit fly, and to say that the gene for such and such a character is situated at such and such a spot on chromosome 1, 2, 3 or 4.

Naturally we expect the same to be true of man. We know that the genes for blood clotting and colour vision must be on the X chromosome, and doubtless as time goes on the location of the other genes will be settled. It will take centuries of endeavour but we cannot doubt that the facts as discovered in animals more amenable to experiment than man will apply to inheritance in man also.

In the paragraph just preceding the last, the word "mutation" was slipped in without explanation. It is a fact that suddenly new characters appear in genetic experiments. Sometimes the change, the mutation, is spontaneous. In others it can be induced by bombarding cells with X-rays or by poisoning them with colchicine. And these mutations breed according to Mendelian rules. Apparently some chromosome has been disturbed in its make-up. A gene has "gone wrong" or dropped out or reduplicated. Such a mutation is hæmophilia in man; another is colour blindness; another albinism. (We must assume that colour vision originally must have been the mutation and colour blindess the normal because animals lower in the scale of evolution than man are colour blind.)

The subject is mentioned here only because the study of these mutations has given the geneticist (i) a basis upon which to found a theory of the method of evolution, and (ii) a further means of mapping the chromosomes.

The above two chapters give only the slightest sketch of the results obtained by intensive research upon inheritance and its relation to chromosomes and the modes by which characters are handed on from parents to offspring. Much the most profitable study has been made on such animals as the fruit fly, the moths and butterflies, grasshoppers and so on. There is reason to believe that mammals and man come into the picture. The position of the genes in the chromosomes of the fruit fly have been fairly fully mapped and a beginning has been made in man. There is little doubt that in years to come what is true of the fruit fly will be shown to be true of man and that we shall be able to account genetically for "the family face" and the inheritance of the physical basis of personality.

CHAPTER VII

The Nervous System

So far we have put up some sort of a case for believing that inheritance is governed by the genes; that in addition to such superficial things as eye and skin colour, deeper seated modifications are dealt out and handed on with the chromosomes and that every physical character is inherited according to verifiable rules.

within the skull and the backbone. It is thus highly centralised, and its central offices, so to speak, consist of hierarchies upon hierarchies of government. In man an enormous degree of centralisation has taken place and a recently and highly developed portion, called by Sherrington the "roof brain", has gathered much, though not all, of the governance into its hands.

The unit officers of these hierarchies of governments are the nerve cells (or better named "neurones"). There are some 2,000,000,000 of them—a huge government and civil service—whose tasks have to be co-ordinated, regulated and rendered almost autonomic. It is difficult in practical life to manage a small bureaucracy of a million or so. It becomes effete, out of touch, unprogressive. But here is a bureaucracy (one officer to each inhabitant of the earth in number) smoothly carrying on the government of the body—whereas in social affairs on this planet we are still several centuries away from efficient government or co-ordination.

The nervous system (unlike other organs such as the heart, or liver) consists of units that differ in size, shape and appearance as different plants differ among themselves. The cells of the liver are all alike. Moreover, the cells of a frog's liver are not very unlike those of a human being, though their cousinship is at very many removes. But the neurones of the nervous system are extraordinarily unlike each other in size and shape—much more so than the human liver cell and the frog's. Yet there cousinship is close. They may be spherical, spider-shaped, like fishing rods, like trees, or the seaweed laminaria, or even that of the Sargasso sea. Their bodies may be tiny in diameter—some two fifty-thousandth parts of an inch across, or they may be just visible to the naked eye. Their branches may be tiny in extent, sufficient to keep two next door neighbours among the packed nerve cells in touch with one another, or they may run from the roof brain down to the end of the spinal cord—a distance of about three feet.

The function of this amazing system "of lines and nodal points, gathered together at one end into a great ravelled knot the brain, and at the other end trailing off to a sort of stalk, the spinal cord",[1] is to send messages to the muscles which will make the body move effectively as a whole.[2] And as there are grades of activity from a single contraction of a set of muscles, as in

[1] Sherrington, *Man on his Nature*, p. 223.
[2] Adrian, quoted by Sherrington.

the knee-jerk, to the manifoldly more complex reactions of the body as in running or the following of a line of print by the eyes, so we find (i) areas (or rather volumes) of nerve-cells grouped together to preside over some simple reaction and (ii) tracts—long branches of nerve cells—linking up the activity of one group of nerve cells with that of another, so that their joint actions may be mutual and co-ordinated.

A simple reaction such as the knee-jerk—which takes effect almost inevitably when the tendon below the knee of a leg lightly thrown over the other knee as in sitting be tapped—is spoken of as a reflex. Other simple reflexes are the blinking of the eye when something, even a snowflake, threatens it; or the watering of the mouth when its mucous membrane is painfully disturbed. More complicated reflexes are those of sneezing, coughing, and breathing. Still more complicated are the co-ordinated movements of fore and hind limbs in animals or the arms and legs of a human being in walking and running. As complicated are the movements of the six muscles controlling the position of each eye so that the flight of a bird seen from a train—or that of an aeroplane seen from another aeroplane—may be effortlessly followed. All such reflexes are, in ultimate analysis, the reaction on the part of the body to a stimulus or group of stimuli playing upon the sense organs of the body. They carry on till they reach their goal or are interrupted by some other activity of the body. The nervous system reacts in a machine-like way, the parts of the machine being inherited according to patterns and styles determined it may be supposed, by the genes.

The spinal cord controls mainly the reflexes of the limb movements. The lower end of the stalk of the brain controls those reflexes which have to do with breathing, with supply of blood to the various parts of the body, with the activities of the heart and the digestive system. Higher up we meet a compact group of nerve cells and their branches, the little brain, which guides and reinforces the activities of muscles. Still higher, in the optic thalamus as it is called, we meet a structure whither all sensory impulses, started in whatever part of the body, run; where they are sorted out and whence are relayed impulses (*a*) to the big knots of motor nerve cells known as the corpora striata and (*b*) to the roof-brain (see below). This thalamus seems to be the seat of all emotional reactions, and beneath it, in the hypothalamus, is a centre or group of centres, from which run nerves controlling

the muscles, etc., which enable us to "register" emotion. (Of this more anon.) Above and beyond the thalamus lies a tremendous sheet of tissue called by Sherrington the "roof-brain". This is enormously developed in man. It is rudimentary in the bird, the reptile and the amphibians. It is small in the dog; much larger in the ape but only in man does it reach an overwhelming development. Its functions apart from acting (i) as an end station for all sensory messages, except those of pain which do not travel beyond the thalamus, (ii) as an originator of "willed" movements of muscles and (iii) as centres for reflexes connected with vision, balance and hearing, are those of (iv) guidance of the reflex actions under control of "lower" reflex centres, of (v) blending into a whole the manifold sensory impulses which surge up from the "lower" parts of the nervous system, and of (vi) deciding upon the reactions to be made or the reflex actions to be suppressed. In addition to this we think of the roof-brain as the seat of the mind, that unanalysable, unplaceable constituent part of ourselves of which we are conscious though it seems to have no parts nor magnitude.

The anatomy of the parts of the nervous system does not so much concern us as its activities. No nerve cell is continued into its neighbour. There is a physiological separation between them and this junctional tissue we term a synapse. Let us take a simple reflex such as the withdrawal of a part of the body when a painfully hot object is touched. There is sensory apparatus in the hand. This is awakened to activity by the hot object. Nervous impulses pass up a sensory nerve to the spinal cord. Here they break through the resistance of a synapse (really group of synapses) and rouse to activity a motor nerve cell (really a group of motor nerve cells). These nerve cells fire off a volley of nervous impulses along the motor nerves to the muscles (the flexor muscles) which draw the injured limb in towards the body and away from the hot object. The structures, thus working together —sensory organ, sensory nerve, synapse, motor nerve cell, motor nerve and muscle—we call a reflex arc. Upon such reflex arcs (never quite so simple as the one described) all the reactions of the body depend. The paths may be longer, the number of nerve cells and of the synapses between them be greater, and the motor side of the reaction be much more complicated. None the less the pattern is the same. We meet several places in the reflex arc where the nervous impulses must leap a gap in order to wake the next adjacent cells to activity.

Now this gap offers greater resistance at one time than another. Fatigue and drugs such as alcohol, opium and chloroform increase the resistance. Other drugs such as caffeine, strychnine and tetanin reduce the resistance. In some people the resistance is permanently high and in others permanently low. One person hardly moves at a sudden sound. Another jumps "half out of his skin". The first is a placid individual, the second "highly strung".

It is notorious that these differences can be seen from the moment of birth—there are placid babies and fretful babies. Is it not possible that these differences—differences in the reactivity of the nervous system—are inherited? Are not the genes concerned in the inheritance of highly irritable reflex arcs?

We have spoken above of a hierarchy of governing centres in the nervous system. There are the old-established ones which govern the ancient reflexes of standing, walking, running, breathing and the circulation of the blood. There are later developed centres co-ordinating the reactions of the body as a whole. And then, finally, there are those most recently developed sheets of nerve tissue called the roof-brain. As we proceed through these hierarchies we find them more and more easily put out of gear. Whereas it takes a large dose of chloroform to upset the breathing reflexes, quite a small dose will stop the activity of the roof-brain.

Again we have to recognise persons with highly resistant roof-brains and those with less resistant. Some people work under a concentration of alcohol, nicotine and fatigue products which would render others useless members of society. It is exactly the reactions of these "higher" centres upon which so much of personality depends. A person with highly resistant roof-brain cells will show a different personality from that of one with less resistant cells. Is it not possible that the genes so endow one person with a resistant nervous system and another with a sensitive system?

Especially is the personality seen in emotional display. Reactions may be uncoloured or coloured with emotion; and as the colour varies from person to person so the personality is different. The Oxonian walks along the street as if it belonged to him. The Cambridge man as if he doesn't care to whom it belongs. The difference in emotional reaction to the street gives them different personalities. (Of course this is an illustration of the effect of nurture rather than nature or inheritance, but it

illustrates the point; that emotional reaction affects personality.)

Some natures are highly emotional and in them either the optic thalamus is over-developed or the roof-brain has not been able to keep a sure hand and curb over the thalamus. Again, may it not be the genes which determine the relative sizes and efficiencies of the roof-brain and the thalamus?

Emotional life, as we have said, seems to depend on the thalamus, and just below the thalamus and in close connection with it are the supreme central offices which control the activities of the heart, blood vessels, alimentary tract, digestive secretions and so on. It is a commonplace that these organs are affected in emotion. In painful emotion the face blanches, the hair stands on end, the pupils of the eyes dilate, and eyeballs protrude, the mouth is parched, the heart-beat increases in rate and force and there is an uncomfortable sensation in the pit of the stomach. X-ray shadows of the stomach show that in painful emotion it loses elasticity and the lower end drops below the line of the hips. All digestive movement ceases. Chemical analysis of the blood shows an increase in the sugar called glucose. One and all, these reactions are those given when the path of outflow from the central nervous system to the viscera, called the "sympathetic nervous system", is stimulated. It might be thought that the body has a special part of the nervous system specialised to "register" painful emotion, but the better theory is that this system has been developed to enable an animal to meet an emergency. All the physical and chemical reactions to an emergency make the animal more able to cope with the situation —by fight or by flight. The emotions accompany these reactions. None the less, emotional folk must use the sympathetic system more than placid people. There is another outflow to the viscera, which antagonises the sympathetic. This is the parasympathetic (or false sympathetic) which arises from the nervous system in two places—the stem of the brain, and low in the spinal cord. As its main constitutent is the vagus nerve, that vagabond nerve which wanders to and fro over the viscera seeking what it may control, the term "vagotonic" has been applied to those people in whom the parasympathetic gets the upper hand. Parts, if not the whole, of the parasympathetic system are active during pleasurable emotions, in particular during the prelude to and the consummation of *re venerea*.

Years ago it was proposed to divide people into two types, the vagotonic and the sympathicotonic, and although this

classification has not been widely accepted, or rather was accepted and then dropped, the writer is convinced that there is much in it. Of course it must not be supposed that the two types are Mendelian allelomorphs or that there are not gradations between the two types. People, however, appear to belong to one group or to the other, but just as some people in this country are more democratic or socialistic than others, so are some more vagotonic than others. Vagotonicity and sympathicotonicity must ultimately depend upon the development of the hypothalamus, and the emotional tone of a person depends (i) on the development of the thalamus and (ii) the amount of control the roof-brain has acquired over the thalamus reactions. It is difficult not to believe that such characteristics are inherited, and, indeed, have proved of great importance in evolution.

One last topic, on which we are on surer ground, may be considered before we leave the nervous system. Size of brain matters and the surface area of the cerebral hemispheres—the roof-brain—matters. The enormous animals of geological ages had brains about the size of a walnut. But dominance in evolution has depended on centralisation of government of the body in the brain. Moreover, the capacity for intelligence depends on the convolutions of the roof-brain rather than on its brute weight. Man has not only an enormous roof-brain as compared with even the highest apes, but intelligence is related not to mere size of the brain but on the intricacy of its convolutions. And just as the shape, say, of such superficial characters as the curve of an eyebrow or lip depend on inheritance, we can hardly doubt that the size of the roof-brain and the number of its convolutions depend upon inheritance. And as intelligence largely determines personality, one main basis of personality must be determined largely by inheritance. We are what we are largely because we inherit a definite type of nervous system.

. . . . .

An inviting avenue opens up here: whether the intense hierarchical development of control in the nervous system is not an argument for dictatorship in the body politic. The temptation to stroll or even give more than a glance along this avenue must be resisted. First: it is not in the least germane to our discussion; second, such an "argument" is no argument at all, but an appeal to analogy; third, the master mind of research into the activities of the nervous system gives this as his verdict on its Totalitarian possibilities:

"We might imagine this principle (convergence of control) pursued to culmination in final supreme convergence on one ultimate pontifical nerve-cell, a cell the climax of the whole system of integration. Such would be a spatial climax to a system of centralisation. It would secure integration by receiving all and dispensing all as unitary arbiter of a totalitarian state. But convergence toward the brain offers in fact nothing of that kind. The brain region which we may call "mental" is not a concentration into one cell but an enormous expansion into millions of cells. They are it is true richly interconnected. Where it is a question of 'mind' the nervous system does not integrate itself by centralisation upon one pontifical cell. Rather it elaborates a million-fold democracy whose unit is a cell."[1]

CHAPTER VIII

The Endocrine Organs

One way of describing the function of the nervous system is to call it "integrative". It welds the body into a whole or integer. Its cells, which number millions, each capable of an independent life and wielding its individual powers, have to be co-ordinated in their activities.

"The human individual is an organised single family of cells, a family so integrated as to have not merely corporate unity but a unique corporate personality. The doings of this cell-assembly are—itself supposes, society allows and the Law decrees—those of a being which is one, a unity. Yet each of its constituent cells is a life centred in itself, managing itself and breathing for itself, separately born and destined separately to die. Further, it is a life helped by, and in its turn helping, the whole assembly, which latter is the corporate individual; such co-operation is one key to what we may call the incorporation, or the integration, of the individual."[2]

One mode of integration, the master mode, the emergency meeting mode, is by means of the nervous system. But there are other modes. One is merely anatomic. The cells are tied together much as a parcel is "integrated" by string and brown

[1] Sherrington, *Man on his Nature*, p. 277.
[2] *ibid*, p. 73.

paper. They are hung on and tied to a skeleton—internal girders, as it were. Another, and the mode we are to study now, is by chemical means. Just as a commonwealth may be integrated by wireless and the electric cable, so is the body by the nervous system, and just as the activities of an army are integrated by transport, so is the body by means of the circulatory system. Head offices which have to bring about changes in the body can rely on chemical messengers, termed hormones, which they post into the circulatory system. These head offices are termed Endocrine organs because they secrete their hormones directly into the blood.

Now, just as the type of nervous system we inherit may influence our personality, so too will the endocrine organs. In fact they have been called the "glands of personality", so markedly do some of them influence individuality. Some have gone further and termed them the glands of destiny, suggesting that we inherit our endocrine make-up and that make-up stamps our personality for good or ill. The change seen in Napoleon Buonaparte in and after his Moscow campaign has been plausibly put down to failure of his pituitary gland. Could that have been forestalled who knows what the state of Europe would have been? It is a fascinating pursuit: fitting each of the great and bad men of history into particular endocrine types, but the reader is warned that speculation along these lines has far outrun what the scientific basis would warrant. We are still, for instance, in doubt concerning the functions of the thymus gland; yet the rise and fall of such an one as Oscar Wilde has been ascribed by the over-enthusiastic to the dominating effect of his thymus.

Some of these endocrine organs do influence personality, as we shall see, but we have to be careful not to go beyond the findings of endocrinologists and not to assume that a type of personality accompanying a gland disturbance is the direct result of that disturbance. For example, lack of a specific secretion of the pituitary gland will cause a person to be a dwarf. It is noticed that dwarfs are perky, aggressive, exhibitionist and arrogant, but it is not true to say that the lack of this secretion is the direct cause of aggressiveness. It is the play of environment on the character of the dwarf which has produced it. Could he have been brought up in more sympathetic surroundings, or even among pigmies, it is probable that his character would be different. It is the old problem of nature versus nurture. We

have to be persistently careful when discussing endocrinology not to attribute a change in personality seen to accompany an alteration of the secretion of a gland to that alteration. Thus a boy may have a horse-like face as the consequence of over-activity of the pituitary body. At school this is bound to be remarked upon. He will be nicknamed "horsey". If he resents this he may react in sundry unpleasant and asocial ways. If on the other hand he does not mind it will make no difference to his behaviour. It would be clearly wrong to ascribe any development of asocial characteristics to pituitary overactivity.

The doctrine of hormone control, hormone integration, was slow in development. Somewhere in the middle of last century it reared its head, but it obtained its first real hold as the result of the discovery that the secretion of the pancreas is integrated with the passage of food into the first part of the small intestine by a chemical substance, a hormone, which could be extracted from the mucous membrane of the small intestine. It was the name which did it. Shakespeare is reputed to have said "What's in a name? A rose, etc." In biology, and particularly in biochemistry, a name means much. Bayliss and Starling christened this new-found internal secretion of the mucous membrane a "hormone" and postulated a series of hormones, chemical activators, which are secreted by one organ into the blood, to integrate the activities of other organs of the body at remote spots. There arose an idea of an integration of "chemical" quality. And then there was an orgy of research on hormones and as bad an orgy of nomenclature, but by now the work has settled down into the respectable study called "endocrinology" which, while still young, has added greatly to our knowledge of the way in which the body is integrated. When rapidity of action is essential, then the body is integrated through the nervous system. When the action may be slow without harm or even extremely slow and prolonged, then the body uses chemical means of control, not nervous.

A good example of slow chemical co-ordination is that of the growth of the bones. Growth is rarely complete till a person has reached adult age. Therefore for twenty years the rate of growth of each bone in the body has to keep pace with the rest. Thigh-bone, backbone, neck, hands, feet, skull, nose; all have to grow at approximately the same rate, and this co-ordination is accomplished by minute doses of an internal secretion from the pituitary gland, poured unintermittently into the circulatory system from

before birth till (actually) old age, and not merely adult age, is reached. The rate of growth of the different bones is co-ordinated by a hormone; the body is integrated chemically.

The glands of internal secretion, the endocrine organs, which we will particularly mention as interesting us, are the thyroid, the parathyroid, the pituitary, the thymus, the pancreas, the suprarenal bodies and the ovary and testis. One and all have some influence on personality, though whether this is direct or is the result of the play of environment on an abnormal person, we must carefully consider in each example.

THE THYROID

The thyroid is the classical example of a gland influencing personality. It is a small butterfly shaped gland on each side of the Adam's apple and with an isthmus connection, the two halves crossing the middle line. Most of us are unaware of possessing such an organ, but at times it enlarges, and people with enlarged thyroids are seen in this country in the Pennines (particularly in the Peak district, which gives the trouble the name of Derbyshire neck), in the Cotswolds and the Mendips. Abroad it is seen in mountainous regions such as the Pyrenees, the Alps, the Caucasus, and the Himalayas. In the new world the Andes, the Rocky Mountains and the Great Lakes of North America are the centres of thyroid trouble.

Sometimes children (and animals) are born without thyroids, and we see what is termed cretinism. Such a child never "grows up", never acquires a personality much above that of an animal which shows its wants by grunts and cries. All the activities of the body are damped down. Truly the adjective "sub-human" can with some justification be applied to a fully cretinous child. Milder degrees of under-activity of the thyroid result in backwardness, slowness of learning to walk and talk, failure to fit into society, slowness of uptake. "There are," said a society physician once, "numbers of women in Society who would degenerate into slatterns, were it not for thyroid medication."

One characteristic of an adult with mild under-activity of the thyroid is great sensitiveness to cold. He has cold hands and feet; uses hot water bottles even in daytime; wears lots of clothes; drives, even in hot weather, in closed automobiles. (His first response to treatment is a feeling of "thawing out".) He also has difficulty in mental activity, is forgetful, has an amnesia for past life, finds it hard to concentrate, lacks initiative and capacity

to decide on or carry out a plan. Many of these characteristics come into the make-up of personality. Others, such as obesity, chronic headache, constipation, anæmia, sterility and impotence, though not belonging directly to "personality", may none the less influence its development. The thyroid therefore seems to be a good example of a gland influencing personality, and this impression is confirmed by the results of thyroid therapy. The cretinous child is born to parents with thyroid defect and the trouble thus seems to be inherited. The defect in the cretin is lack of the internal secretion of the thyroid, which is a protein compound of a substance thyroxin, isolated by biochemists from the thyroid gland and actually synthesised in the laboratory. Supply this substance as dried ox thyroid or give thyroxin, and a marvellous change in the cretinous child takes place. Its apathy is sloughed, its vacuity disappears, a human personality develops. And so long as the medication is continued this growth of a personality is maintained alongside of the development of normal physical faculties. A cretin plus thyroid medication becomes a normal person. The same is true of an adult with under-activity of the thyroid. A few grains, perhaps even less than one grain a day, of desiccated ox thyroid given by mouth will turn an ugly, hairless, coarse-featured, apathetic and slovenly being into a pleasant looking, lively and charming personality. The medical literature is full of such transformation scenes, one noteworthy example being that of a woman whose treatment began at the age of 65, when she looked like a bald and stupid old man and who died thirty years later in her 95th year the picture of a charming, lively, elderly lady.

Here, undoubtedly, is a gland controlling personality. If one is born with a deficiency, one's character pays the price. Do our genes control the size of the thyroid and its capacity for functioning? It is possible. There is the axolotl, that Mexican amphibian, which seems to have dropped a thyroid-developing gene from its chromosomes and so never "grows up". And there are children born with an under-active thyroid to parents who seem normal. If it can be shown that the tendency to under-active thyroid be inherited and transmitted via a male parent the case for the genes and the thyroid would be complete, but there are obstacles to this theory. (i) Cretins are usually born to parents with thyroid deficiency; (ii) alleviate this deficiency in the mother and the children are normal. (iii) Treatment of people, more particularly children, with minute doses of iodine will reduce thyroid trouble

almost to vanishing point. This has been shown to be true in Switzerland, in the United States of America, and in New Zealand. In fact, much thyroid trouble is due to faulty nurture rather than to inheritance, and it may prove in the long run that it can be eliminated, not by eugenics, but by assuring a satisfactory intake of iodine in food and water (and before birth from the maternal blood) at all ages. The function of the thyroid is to manufacture thyroxin, an iodine compound of tyrosine and phenol. Both the iodine and the tyrosine come from the food eaten, and if the food be deficient in iodine—it can but rarely be deficient in tyrosine—the thyroid cannot fulfil its task. It is odd to think that the sort of personality we develop depends upon our obtaining a minute amount of iodine per day—one thousand-millionth or perhaps two thousand-millionths of our body weight per day.

We have not finished with the thyroid. Sometimes it is over active and then the picture is quite other. Instead of obesity we have loss of weight, the skin instead of being puffy is thin and delicate, the hair is soft, the appetite large, and cold is not felt. Such people appear to the normal fanatic about open windows. There are tremors of the muscles and fullness of the eyes, which in acute cases stare Gorgonwise from the head. The sympathetic and parasympathetic nervous systems are over-active, especially the former. Along with these physical signs go many psychological changes. There is restlessness, nervousness, psychological excitement and insomnia. There may be an anxiety neurosis. In acute cases a state of extreme excitement, dissociation of thought, confusion, delusions and hallucinations may occur, and this may end in a fatal maniacal crisis.

Again we observe a dependence of the personality on the functioning of the thyroid. Over-activity of this gland may transform a serene and placid personality into that of an anxiety-ridden neurotic. Our thyroids condition the development of our personalities. We tread a narrow knife-edge between over- and under-activity—how narrow we do not accurately know. One Harley Street physician equates it to less than a grain of desiccated thyroid per day. Others put it somewhat higher, and in view of the benefit conferred by thyroid dosage on some people it may be asked whether a mild over-activity is not a useful characteristic? It has been suggested that these people whom we all admire and envy, the alert, energetic folk with great initiative and facile emotionality, inexhaustible doers, the up early and late

to bed insomniacs and incorrigible planners are blessed with a thyroid working just a little over the normal.[1] Could we not transform our sluggish personalities into something rich and strange by a daily dose of thyroid?

Alas! Hoskins, Director of neuro-endocrine research, Harvard Medical School, to whose latest book, *Endocrinology*, this chapter owes most of its data, thinks not. Giving thyroid to the normal person "gives rise to no enrichment of the personality but merely to an amount of ill-natured restlessness".[2] None the less he writes . . . "We are what we are in no small measure by virtue of our thyroid glands. Our development before birth and through infancy depends upon their functional integrity. A pinch too little of thyroxine spells idiocy, a pinch too much spells raving delirium. Is it a final beneficial waning of a thyroid secretion that permits the untroubled approach of the last long sleep?"[3]

THE PARATHYROIDS

Buried, or half buried, in the thyroid tissue are two (or more) pairs of tiny glands called the parathyroids or "false thyroids". They appear like aberrant pieces of lymph glands, and misled by such appearance, research workers for many years. It is now known that they control the amount of calcium in the blood. The normal amount is very small, viz. 0.008 to 0.010 per cent., but should that percentage fall to 0.006 or less there is trouble in store. There will be headache, a feeling of weakness and radiating pains in the limbs; apprehensiveness and consciousness of "quiverings" throughout the body. Then will come cramp, particularly of the muscles of the fingers and palms of the hands. This spreads to the wrist, forearms, feet and finally to the trunk muscles. If it extends to the muscles of respiration there is always a possibility of death by asphyxia. All these symptoms are the result of depletion of calcium in the blood, and therapy is concerned with raising and bringing back to normal the calcium in the blood by (i) high calcium feeding, (ii) injections of calcium salts, and (iii) use of vitamin D and allied substances to increase the absorption of calcium from the alimentary tract.

[1] The writer is thinking of one such, put on desiccated thyroid to alleviate rheumatism, working it up to 7 grains a day, and leading an existence such as that described above.

[2] Hoskins, *Endocrinology*, p. 95.

[3] *ibid*, p. 101.

Milder stages of deficiency do not lead to such devastating results, but are none the less disturbing to the health and the psychology. McCollum writes that "No one with blood containing slightly too low a calcium content and markedly low phosphorus content has a wholesome attitude toward life. The accompanying irritability, lack of agreeableness, and lack of serenity must be an important consideration in determining the attitude . . . toward home, school and associates."[1] Others have given evidence that raising the calcium level in the blood markedly improves the personality in children suffering from too little calcium. Some had developed the typical convulsions followed by mental depression and irrational speech. There was maniacal excitement with screaming, fighting and tearing of clothes. The condition was relieved by parathyroid therapy. Another physician reports a type of "personality disorder" in which the parathyroids seemed to play a role. The subjects were so touchy as to fly into ungovernable rage upon the slightest provocation—an unfriendly look or a mildly critical comment. Under treatment with parathyroid extract supplemented by calcium and sunlight a striking reformation occurred. Below 8 milligrammes of calcium per 100 millilitres of blood and you have an irritable and unwholesome personality—above, and you are a normal human being. We are reminded of Mr. Micawber: "Income, £20 a year. Expenditure, £19 19s. 6d.—happiness. Expenditure, £20 0s. 6d.—misery."

THE PITUITARY

We come now to the most exciting of the endocrine organs, for not only does it possess a number of secretions but it controls and co-ordinates the activities of the other endocrine organs. It has been dubbed the "conductor of the endocrine orchestra".

It is a tiny gland tucked away in a bony cavity called the "Turkish saddle" (sella turcica) between the brain and the roof of the mouth. It consists of two portions, the anterior, formed from an outgrowth of the mouth cavity in early life, and the posterior, from a downgrowth of the brain. Many years of research by many workers have shown that the anterior lobe has a remarkable influence on growth and on the organs of reproduction together with strikingly stimulating effects on the thyroid, the cortex of the suprarenals and the islet tissue in the

[1] Quoted by Hoskins, *ibid*, p. 115.

pancreas. Extracts from the posterior lobe raise the blood pressure, stimulate the muscles of the alimentary tract, regulate the water flow from the kidneys and cause the uterus to contract.

The anterior lobe co-ordinates the growth of the bones of the body and the onset of puberty. The results of over- or under-activity of the gland vary with the age of the person. If there be over-activity in a child there is overgrowth and early sexual maturity. The giants of actual fact and not of mythology are the result of over-activity of the pituitary gland in childhood. When the height produced is excessive—say, over 7 feet—the result is usually debilitating. The heart has so much extra work to do and the blood vessels of the legs are usually not resistant enough to the increased hydrostatic pressure. The giant, physiologically, is an ill-engineered piece of machinery. It does not necessarily follow that the sex maturation follows the growth. The two functions may be dissociated, and as over-activity of the pituitary is sometimes followed by under-activity, the functions get out of step with each other. Giants are not necessarily sexually potent, but it is often observed that children showing in their growth rate over-activity of the pituitary are also sexually precocious. We know from animal experimentation that the anterior lobe of the pituitary not only stimulates growth in length (making, say, a dachshund more of a dachshund), but that it causes (i) an early maturation of both ovaries and testes and so brings on prematurely the signs of adulthood, (ii) a luteinisation of the ovaries (see below), thus aiding the control of pregnancy, and (iii) a flow of milk from active mammary glands. Should over-activity supervene in adulthood the picture naturally is different. The bones cannot grow in length, but they do grow at the extremities. The person so afflicted will notice that shoe and glove size and in man hat sizes as well increase. The fingers grow spadelike at the tips and the hands and feet are coarser. The face alters in becoming horselike. Frontal ridges increase, the cheek bones enlarge, sometimes the upper jaw and sometimes the lower—sometimes both—enlarge and the teeth become spaced and the bridge of the nose becomes more prominent. All the "points" grow, whence the name of the state "acromegaly". With this increase there may be increase of sexual activity—even as far as satyriasis or nymphomania.

Under-activity, as might be expected, produces exactly the opposite of the above. There are pituitary dwarfs and pituitary

eunuchs. But one result of under-activity of the pituitary is the laying down of large quantities of fat. This at times may become almost intolerable. The fat people of the circus side-shows and of literature (e.g. the fat boy in *Pickwick Papers*) are probably examples of under-activity of the pituitary.

Now many writers on endocrinology have associated temperamental characteristics with over- or under-activity of the pituitary gland. Some have spoken of the pituitary as though it were the great driver of personality. They have pointed to the massive supraorbital ridges, cheek-bones and noses of the great Victorians—e.g. Huxley, Darwin, George Eliot—and accredited them with increased pituitary action. Believe it or not, even Napoleon has been "explained" as a hyperpituitous man, though he was almost a dwarf, early ran to fat and led a sexual life, which, though erratic, was not so lurid or quite so polygamous as usually depicted. Whatever drive Napoleon had it was not, one would imagine, conditioned by the pituitary!

None the less there is some evidence, both empirical, observational and experimental, that the pituitary influences personality. Over-secretion of the growth hormone seems to be accompanied by intensive living, courage, initiative and forcefulness of character, whereas with waning of secretion there supervenes lassitude, timidity and failure.[1] This observation is strikingly confirmed by an experiment by Collip. He removed the pituitary gland from a wolf-hound. "From an aggressive pugnacious creature it was converted to a whimpering coward. When treatment with pituitary extract was instituted much of its former behaviour was restored."[2]

More startling still are the results of injecting an extract of the anterior lobe of the pituitary named provisionally prolactin (because it stimulates the secretion of milk by the mammary gland) into fowls, fishes and virgin doe rats. It induces broodiness in fowls, it stimulates nest-building fishes to make nests, and virgin doe rats, to whom a newborn rat is a matter of indifference if not indeed a dainty morsel of food, to maternal solicitude for the young. Though no report of its use in that direction in human beings has yet been made, possibilities are opened up of changing the personality of spinsters.

But there are, none the less, observations which go to show that the personality of human beings may be influenced by

[1] Mayers. Quoted by Hoskins, *Endocrinology*.
[2] *ibid.*

injections of extracts of the anterior lobe of the pituitary. The sufferer from pituitary derangement is aware, painfully aware, of his difference from his kind. One with under-activity causing marked adiposity "looks askance at chairs, he abhors public conveyances and the, to him, diminutive seats in halls and theatres. He blocks aisles and passage-ways. The regular route of the seriously obese is through grief, sensitiveness and despair to isolation." Again, the fat boy may become resentful at ill-natured gibes and in the end aggressively sadistic. Of 279 youngsters in whom the pituitary was abnormal 53 had behaviour problems such as moroseness, bullying, disobedience, lying, thieving and vagrancy. There was improvement with pituitary extracts, but how much was due to this treatment and how much to psychological handling it cannot be said. Other workers have reported similar results.

None the less, the observations show that the pituitary has an influence upon personality. It may be that it is direct, or it may be that the change in personality is due more to the reactions of the abnormal person to a hostile environment than directly to under-activity of the pituitary. The abnormal person may be morose, a bully, disobedient, a liar and a thief directly because his pituitary is not exerting a due influence, or he may have become so because he feels at a disadvantage in coping with affairs in a world of well-endowed folks and compensates for his inferiority by these unpleasant reactions. Whichever interpretation we put upon the observations it is clear that the pituitary influences behaviour.

THE THYMUS

The thymus must be mentioned, though it is still doubtful whether or no it be an endocrine organ, for in the past much has been made of its influence on personality—the vagaries of Oscar Wilde have been attributed to over-activity of that organ. It forms two large masses situated in the upper part of the membrane (the mediastinum) which divides the chest internally into two symmetrical halves. It grows rapidly in man till the second year, then more slowly, and at the age of puberty it begins to regress and in adult life its presence is shown only by rudiments. The regression starts earlier in girls than in boys and in Jews earlier than in Gentiles. In cattle it is termed the neck sweetbreads, and to-day (since the pancreases of animals slaughtered

for food are needed in the manufacture of insulin) is the chief source of that gourmet's dish.

There is some slight evidence that it has an internal secretion. Its involution at puberty is suspicious. Its decrease in pregnancy suggests that it has something to do with reproduction. Castration in rabbits, guinea-pigs and cattle delays its regression and points in the same direction. These observations suggest that there is a reciprocal antagonistic relation between the thymus and the gonads, and it may be that the function of the thymus is to delay the onset of puberty. It is therefore possible that a persistent thymus may result in a repression of sexual activity, but physiologists are by no means agreed about the interpretation of the results of experiments on animals.[1] So for the present we must put a large query mark against its involvement in influencing personality.

THE SUPRARENAL BODIES

These are twin bodies, shaped like a cocked hat, situate above the kidneys (whence their name). As in other animals they are near the kidneys and not necessarily upon them they are often termed adrenals.

They consist of two parts, medulla and cortex—i.e. marrow and rind. The medulla undoubtedly manufactures a very powerful secretion termed "adrenalin", a derivative of tyrosine, the amino acid forming an integral part of most food proteins. And this adrenalin they pour into the blood when there is an emergency to meet. For example: primitive man in a tropical jungle suddenly is face to face with a beast of prey. At this moment the suprarenals inject adrenalin into the blood. This has the following effects: (i) The blood is diverted from other parts of the body, such as the skin and alimentary tract, to the brain, spinal cord and muscles; (ii) its "sugar" content is raised; (iii) the heart beats more forcefully and rapidly. These three things, working together, enable the body to become a much more efficient machine. The man has to put up a fight or to run away. In either case the nervous system and the muscles need all the oxygen and the fuel material they can get. That is why the blood is diverted from skin and viscera to them and why the heart beats better and quicker, and why the blood is enriched with extra grape sugar.

[1] Lovatt Evans. Starling, *Principles of Physiology*, 1941, p. 1136.

The same thing happens in animals, and we note in addition—more than traces of this can be seen in man—the eyes protrude, the nictitating membrane withdraws, and the pupils of the eyes dilate and the hair stands on end. All these things taken together make the animal horrific. It appears much larger than usual, more threatening, more frightening. Every factor which helps the animal to meet the emergency is 100 per cent. active; any which might obstruct or divert energy is inhibited.

The symptoms of unpleasant emotions in man are directly related to the extra adrenalin in the blood. The face blanches, the hair stands on end, the pupils dilate, the eyeballs protrude, the mouth parches, the heart beats faster and there is a queer sinking sensation in the pit of the stomach. This last is doubtless due to the sagging of the tone of the stomach and intestines. The shadow of the stomach seen under X-ray examination has been observed to drop many inches consequent on a painful emotion or idea. The "cold" perspiration of fear is related, not to adrenalin, but to the action of the sympathetic nervous system, which, however, controls the action of the medulla of the suprarenals.

Clearly the medulla has an "emergency" function of more advantage in "the dark backward and abysm of time" than in more modern times, so that until recently, when world wars have become the fashion, the apparatus, though functioning at each outburst of painful emotion, has not been used for the purpose for which it was intended, i.e. facilitation of nervous and muscular activity. There is no overt activity to-day following emotional outbursts, and it is suggested that this induces a sense of frustration. "Worry is worse than work."

In hyperadrenia—over-activity of the medulla—there is pallor, blanched extremities, tremor of the muscles, distressed breathing, high blood-pressure, sweating, nausea, headache, extreme nervousness and anxiety. The personality is bound to be affected both primarily and secondarily. The closure of the blood capillaries blanches not only the skin but the mucous membrane of the stomach and this often leads to gastric ulcer, and the pain and difficulties caused by gastric ulcer may easily produce a deterioration of personality.

The medulla of this gland is apparently not essential to the cat. It, together with the sympathetic nervous system, has been removed by Cannon from many cats. They survived the operation for years and apparently were none the worse, except that

they became mollycoddles of animals. They hugged the radiators or basked in the sun—not for them the fierce emotional life of the normal cat, the dark cold night, the moon and the tiles. They had become "Harvard sissies".

Should this apply to man we might expect that the under-active medulla would lead to a "mollycoddle"[1] nature, and a mild over-activity to that of a "red-blood".[1] It will be remembered that the normal activity of the sympathetic (to which adrenalin is an adjuvant) is balanced by that of the craniosacral nerves, and that sometimes the balance is upset in one direction and sometimes in the opposite. It is possible that the functional capacity of the medulla of the suprarenal decides which way the balance tips. Under-activity and you have a vagotonic mollycoddle; over-activity, a sympathicotonic red-blood. But this is mere speculation.

We have not yet considered the cortex of the suprarenal. This, recent work has shown, has sundry remarkable functions, some of which are bound when under- or over-developed to influence personality. The cortex manufactures a series of substances all closely related to the sex hormones, to vitamin D, to bile salts, to the organiser which determines whereabouts an egg will begin hatching, to some cancer-producing substances, and to digitalin, the drug produced from foxgloves, used in forms of heart disease.

The results of destruction of the suprarenal cortex in man have been known for nearly 90 years. They are anæmia, general langour and debility, remarkable feebleness of the heart's action, irritability of the stomach and a peculiar change of colour (bronzing) of the skin. These symptoms are taken from Addison's original descriptions of the disease in 1855, but later studies of less pronounced cases have added to our knowledge. One of the first signs of impending disorder is loss of appetite. As the disorder progresses, nervous and mental symptoms supervene. First comes insomnia, later irritability, irrationality, poor judgment and un-co-operativeness. Some of these nervous effects are undoubtedly due to the state of the blood and therefore of the fluids bathing the brain. In Addison's disease the kidney loses its power of holding back sodium salts in the blood; consequently it is depleted of sodium and there is an excess of potassium. Such a loss of sodium from the body may be pro-

[1] The terms, sufficiently explanatory, are borrowed via Lowes Dickinson from Theodore Roosevelt.

voked by living on a saltless diet and submitting to hot-air bathing sufficiently prolonged to produce intense sweating. In the sweat produced there is much common salt or sodium chloride.

A week or so of such treatment, getting rid of a third of the sodium in the body, brings on a set of symptoms closely resembling many of those of Addison's disease. There is immense lassitude; distressful breathing on walking up a flight of stairs; inability to think out quite simple mental problems; incapacity for mental or ordinary arithmetic; lack of judgment and inability to carry out the next step in a series of manipulations. So much depends upon the balance of the chemical substances in the blood, and the maintenance of a normal balance depends upon the activity of the suprarenal cortex. If the sodium complement of your blood is lowered, your character changes.

It is not surprising, in view of the relation between the chemical substances produced by the cortex (corticosterone, dexycosticosterone, etc.) and the sex hormones, that defective secretion by the cortex interferes with the sex life of the sufferer. In males there is a loss of sex drive, and as the disease progresses actual degeneration of cells in the gonads. In female animals oestrum (the period of heat) disappears; and degeneration of the adrenal cortex in pregnancy is followed by abortion. Mothers with newborn young cease to produce milk if the adrenals are removed. In human beings, in the later stages of Addison's disease, there is loss of sexual desire, and potency in men and depression of menstruation in women. The secondary results upon personality of such loss of sexuality have doubtless been analysed by various modern novelists.

The picture of over-activity of the gland is much more striking. In the male it leads, should it happen in infancy or early childhood, to an early onset of puberty, often accompanied by overgrowth of the body. A most extraordinary case is that briefly reported in Hoskins' book, *Endocrinology*, so often quoted in this work. It was of a child twelve months old, who had a dental age of three years, bone growth age of five years and a sexual age of eighteen years. That, in other words, means that he was adult sexually at the age of one year. No wonder the patient was mentally retarded for his age, was bad tempered and difficult to manage. That the suprarenal was to blame is probable from the fact that a tumour the size of a golf ball was found above the right kidney. All other organs were found in general to be

normal. Very many examples of over-activity of the suprarenal cortex in men have been described. There is usually extremely high colour in the fat face, remarkable excess of hair all over the body, and often great muscular development, presenting the appearance of a "brewer's drayman". Sometimes there is a high blood-pressure. There can be little doubt that over-activity of the suprarenal cortex influences personality, and it is not uncommon that energetic, muscular, fresh complexioned, oversexed and virile men should be suspected of such over-activity. The term virilism is used particularly to describe the appearance and reactions of people so constituted.

The effect is particularly marked in women and may be the cause of much social and psychological distress. Should it start *in utero* the child born may show marked pseudohermaphroditism. True hermaphroditism consists in the possession of an ovary and a testis, and is very rare in man. It is presumably to be explained by some accidental change of the sex chromosomes in early divisions of the embryo when the genital tissues are being formed. Pseudohermaphroditism is due to faulty development of the secondary sex characteristics after the gonads have developed. It may be due to hormonal influences as in the case of the free-martin. This is a term applied to the female of twin calves when one of the calves is male and the other female and the latter shows such marked secondary male characteristics as to be useless in breeding. It has been shown that such free-martins arise when the twins share the same placenta in the cow's uterus. Twins of mixed sexes never show the free-martin phenomenon if there are two separate placentæ. The occurrence of the male secondary sexual characteristics in the female of a pair of twins sharing the same placenta is plausibly explained by the hypothesis that the male hormone arising from the testis of the male calf influences not only the secondary sexual characteristics of the male but those of the female sharing the same placenta. The blood of the male has access to the organs of the female of the twin through the shared placenta and so influences the growth of the secondary sexual characteristics of the female. The male hormone must be assumed to override the influence of the female hormone arising from the ovaries of the free-martin.

Pseudohermaphroditism may also be determined by over-activity of the suprarenal cortex. Thoroughgoing hermaphroditism may be the result of this *in utero*. "Actually the infants

begin existence as girls, but acquire a superimposed condition of pseudomasculinity. . . . The victims may go through life without even discovering the nature of the grim joke that has been played upon them. . . . Such cases present, of course, many difficult psychological problems."[1]

By no means all cases of pseudohermaphroditism are due to over-activity of the suprarenal cortex, but many are, and it is found by special staining of the cortex that there is in these an abnormally high percentage of cortex cells which secrete sex hormones.

Should over-activity supervene after birth the results may not be so astonishing, but there is a marked tendency to virilism. This may arise at any age. In girls and women the results depend upon whether puberty has been attained or not, but always the disorder amounts to a superimposition of masculinity upon a feminine structure and *temperament*. The following example, related to the author years ago by a London physician, may serve as illustration.

A girl entered hospital complaining of vague abdominal and other symptoms. They were ambiguous, and a specialist called in consultation from another hospital considered that they pointed to derangement of the suprarenal bodies. But the indications were too vague for anything except an "expectant" policy, so the girl was discharged and told to come back again should there be any marked change. This she did some months later. The change was marked indeed. Her auburn head of hair seemed to have invaded her cheeks and chin—in fact, she had begun to develop a red beard. The voice had deepened and become masculine. In the abdomen a distinct growth could be felt, and consequently an exploratory operation was undertaken. A benign tumour was discovered pressing upon one of the suprarenal bodies and was removed.

The sequel was remarkable. Within a short time the bronze beard was shed and the voice resumed its feminine pitch and timbre. The superficial signs of masculinity disappeared. Now the explanation, which is plausible, is that the pressure of the tumour on the cortex of the suprarenal body involved caused it to empty into the blood-stream much more than the wonted complement of sex hormone, and this induced a masculinising effect—a, fortunately for the girl, temporary virilism. The removal of the growth put things back to normal and feminine

[1] Hoskins, *Endocrinology*, pp. 55–56.

characteristics were resumed. We can easily imagine the effect of such a change on the psychological reactions of the person concerned. "Sad is a woman's lot who, year by year, sees one by one her beauties disappear," sings Lady Jane in the comic opera "Patience"; but sadder still she who is overtaken in youth by such a prank of the endocrine organs.

The example given above deals only with two superficial effects, but research has shown much more deep-seated changes to accompany over-activity of the suprarenal cortex in women. Not only may a beard and moustache be developed together with a masculine distribution of hair on the body and a masculine voice, but the skeletal growth is influenced. It becomes more masculine with narrow hips and broad shoulders. There is an athletic type of muscular development and marked physical strength. The tides of sex life ebb and vanish altogether. Often there is a change in temperament towards masculinity: forcefulness, initiative and even arrogance are shown. Some have suggested that the change in old age towards these characteristics along with the tendency to superfluous hair is due to an unbalanced action of the suprarenal cortex. Most of us can think of virile women—athletic, muscular, independent and with little of sentimentality, unless it takes the homosexual turn so common among women—who perhaps have been "virilised" by too active a suprarenal. But here, as elsewhere, we must be careful not to rush into generalisation on a small amount of evidence and to recognise that an unusual temperament is not necessarily *directly* determined by make-up, whether inherited or conditioned by the endocrine organs. The over-activity of the cortex may not produce "arrogance" directly. The woman finding herself abnormal may compensate by "arrogance" or by developing drive and initiative or by exploiting muscular endowment. This would be a secondary effect and not due to suprarenal, but rather to the psychological make-up reacting to the results of over-activity of the suprarenal cortex. Hoskins writes: "Tragically the young woman (i.e. one virilised by too active a cortex) may remain psychologically feminine and yearn for the normal romance which their hard fate denies them." In these the glandular changes have not altered the temperament.

The biochemists have been able to extract from the suprarenal cortex substances which act in the same way as the normal cortex does. That is, these extracts when injected alleviate the symptoms of Addison's disease. Those isolated in crystalline

form all have a formula similar to that of the sex hormones and pass with little chemical change readily into sex hormones. Nor is it only towards the male sex hormones that they change readily. Desoxycorticosterone, which is the most potent of them, is 21-hydroxyprogesterone, progesterone being an essentially female hormone. Consequently it is somewhat astonishing that excess of activity of the cortex should produce masculinisation. We might expect to find examples where such an excess in the male produces not extra masculinisation (as in the brewer's drayman type) but feminisation. A few such have been observed, of which the following is quoted verbatim from Hoskins' *Endocrinology*, p. 61.

The subject was a forty-four-year-old athlete. "His sex life had been vigorous. He was married and had two sons. Within a period of two years his breasts underwent development until they resembled those of a woman. The external sex structures decreased in size, and both sex desire and potency went into abeyance. He gradually gained weight and the body hair became sparse. His features took on a feminine appearance. At operation a tumour of the adrenal was discovered and removed. Within a week remasculinisation began. The breasts receded, the excess weight was lost and the face regained its masculine characteristics. Within a month the sexual organs had regained their former size and sexual activity was resumed."

It takes but little imagination to show how great a change, secondarily if not primarily, such a condition as that described would produce in the personality of the victim of this freak of nature.

THE ENDOCRINE APPARATUS OF THE PANCREAS

Years ago—approximately before 1921—the butcher used to sell us a delicacy called "stomach" sweetbread to distinguish it from the "neck" sweetbread, the thymus. This stomach sweetbread is the big digestive gland called the pancreas. It has disappeared from most butchers' shops, because it is needed by the manufacturers of drugs as a source of insulin, the substance injected into the diabetic to alleviate the effects of his diabetes.

The pancreas is a digestive gland: it secretes into the small intestine ferments which carry out the main digestive functions of the alimentary tract. It makes three (at least—possibly more) intensely powerful ferments which tear in pieces, chemically, the

three main substances found in foodstuffs. But the pancreas is more than a digestive gland. There are little patches of tissue in it which do not appear to secrete into the duct of the pancreas. They have no connection with that duct. They are islands of cells, surrounded on all sides by a sea of tissue undoubtedly given over to producing a digestive juice. The island tissue—called the islets of Langerhans—if it does anything at all must secrete into the blood-stream.

That it does so took some time to establish; and to find out what it secretes, much more time. What this secretory substance, insulin, actually *does* is not yet wholly clear, but some of its activities interest us in our search for the influence of glands upon personality.

Animals deprived of their pancreas become diabetic. Human beings with diabetes are found on their death sometimes, though not always, to have a damaged pancreas. Sometimes, though not always, this damage involves the islets only. Animals deprived of their pancreatic juice by tying the duct (or ducts) of the pancreas do *not* get diabetes. They have difficulty in digesting food, but not in dealing with the sugar in the blood—i.e. they lack the only primary symptom of diabetes. In the pancreas of the animal with the pancreatic duct tied, the islets remain intact and normal, whereas the rest of the tissue degenerates. Therefore the islets secrete something into the blood which wards off diabetes—helps men and animals to use the sugar in their blood normally and not to waste it.

What this something was took 30 years to discover, and the credit goes to two Canadians, Banting (killed in a flying accident) and Best, now Professor of Physiology in the University of Toronto. A substance has been isolated from the pancreas of slaughter-house animals which is used throughout the world to control the manifestations of the disease in the diabetic.

These manifestations all depend on the patient's partial or complete inability to deal with the sugar (glucose) in the blood-stream. The normal person keeps that sugar within definite limits—0.08 per cent. to 0.15 per cent. On rising, till a few minutes after breakfast, the figure may be as low as 0.08 per cent. It may rise after breakfast to as high a figure as 0.15 per cent., but it will rapidly fall to the 0.10 per cent. level and stay somewhere round there till the next meal, when it will leap up again. Should the figure rise to 0.18 per cent. or over, as the result of a huge feast of sweets, the excess of the glucose may be allowed

to leak into the urine via the kidney—but it is quite rare to see this. The sugar level in the blood is so well regulated that we can eat over a pound of sweets without raising the blood-sugar higher than 0.15 per cent. If all that sugar were allowed to stay in the blood there would be over 0.90 per cent.! It is the production of insulin by the pancreas which enables the body to keep such a tight control over the blood-sugar level.

Supposing the islets are not doing their duty in secreting the full complement of insulin, the sugar in the blood rises above the leak level and is lost to the body in the urine. This would not so much matter if the diabetic did not lose the power to *use* sugar as the normal person does and also to burn fat properly in the body. More and more is he incapable of utilising sugar and burning fat. To get hold of more sugar the body turns on its own tissues and transforms them to glucose, even though it cannot use this. Its level in the blood rises above the leak point and passes away in the urine. To carry away the sugar large quantities of water are feverishly drunk. Huge meals are eaten in the vain hope of producing usable glucose. Huge volumes of water are passed. Worst of all: from the fats is manufactured the poisonous aceto-acetic acid which gives rise to the acetone that scents the breath and the urine of the diabetic with the odour of over-ripe apples. The diabetic's end when untreated is a coma, possibly the results of the accumulation of aceto-acetic acid in his brain. Earlier—in fact, quite early in his career as a diabetic—changes in his psychological reactions may have been observed. He suffers from mild "brain storms"—periods of irrational irritability: his personality is at the mercy of his capacity to use sugar, it seems. If his brain cells cannot use the sugar bathing them they function abnormally. Nor is this a very extravagant statement, as the following will show. When insulin is injected into the diabetic the level of his blood-sugar falls, partly because he can now use sugar, partly because it is stored as glycogen in the liver. It falls, naturally enough, according to the amount injected. A large dose brings it down more than a small dose, so, of course, doses have to be adjusted to the severity of the diabetes: a mild diabetes needs but a small dose, severe diabetes much more.

But suppose an overdose is given. The effect produced is that of lowering the blood-sugar to a dangerous level. Below the 0.08 level the patient begins to feel queer and disorientated; he may get double vision, he may not be able to walk straight, the horizon

plays queer tricks; as the level sinks he may imitate the gait and reactions of a drunken man: lower still and he may faint, have convulsions, sink into a coma and die. The normal among us walk along a na row knife edge between two gulfs: death from too much and too little sugar in the blood respectively. I have a friend whose diabetes dates from the early days of insulin treatment. He is extremely sensitive to an overdose, and as his needs fluctuate unaccountably from time to time he is liable to give himself an overdose. The first time this happened he lost consciousness in that state, but he heard afterwards that it took four people to hold him down. The lowered blood-sugar rendered him not comatose, as happens with others, but like one "fighting drunk". We read in transatlantic textbooks of diabetics under the influence of insulin being accused by the police of being under the influence of alcohol, and of their anger at the accusation releasing adrenalin into the blood-stream and enabling them to recover their "balance". The explanation is that the adrenalin mobilised reserves of sugar in their liver, thus raising the blood-sugar level to normal again.

Some, then, of our reactions to our fellow men are determined by our blood-sugar level, and as our reactions make up what people call personality, this in its turn may be considered to be partly determined by the efficiency of our blood-sugar control.

There are people who suffer from a permanent low blood-sugar level. Life is a burden to them; everything is an effort; temper and emotional instability characterise them. They are usually fond of bread and potatoes and sometimes of sugar, wherefore they may grow fat, which adds to their troubles, because they carry more weight around with them, use up their source of quick energy more rapidly and so lower their blood-sugar. They prefer starchy foods to sugar because they are more slowly digested, and so sugar seeps into the blood at more nearly constant rates between meals rather than in the rush which occurs when cane sugar is eaten. They are often unaccountably irritable before meals. The observant wife will say, "I never discuss anything with my husband till he has had his evening meal." One explorer of uncharted mountains in New Zealand told the writer that the time to look out for trouble on an expedition is just before the evening meal, and commended Elizabeth Robins's *The Magnetic North* for its indication of just that. I have known a man after twenty miles peat-hag hopping on the backbone of the Pennines ready to lie down and die on

the open moorside, but none the less to revive after a little bread and sugar and highly sweetened tea at a desolate farmstead and to face the five miles of moorland track between him and his bed not only with equanimity but with cheerfulness. Much of the irritability of people in such circumstances as those described above can be plausibly ascribed to a low blood-sugar. The fact that physical efficiency is at its lowest ebb before breakfast is explained by low blood-sugar. At first sight one would expect it to be high after the night's rest, and we have all met healthy Britons who pride themselves on doing a spot of work or exercise before breakfast. Foolish folk! Accurate experiment has shown that physical efficiency—the amount of food fuel turned into physical work—is at its lowest ebb before breakfast. It is just then that the blood-sugar is at its lowest for the day and then that the body has no stored sugar to call upon. Physical efficiency rises as soon as the meal has "got into one" and is at its highest level an hour after the beginning of a meal.

Now why should some persons' blood-sugar level be set at a lower figure than others? It is likely that their insulin apparatus works a little too well. We are fairly certain that insulin is secreted in response to a rise in blood-sugar. A large rise probably induces a large output of insulin. This insulin secreted in response helps the liver to store this sugar in an inert form: glycogen. It also swings the body over to burning sugar instead of fat or protein. Consequently the effect of a rush of sugar into the blood as a sequel to swallowing much sugar is, after the initial rise, to cause the blood-sugar to fall even below the resting figure. Supposing that the insulin-making function of the islets is too well developed; supposing that there are too many islets or that the islets are supersensitive; then the possessor of this too efficient mechanism will suffer—yes, suffer!—from a low blood-sugar level.

Of course this is all rather speculative. We have not enough carefully controlled experiments upon man yet recorded to put the plausible view outlined above beyond the possibility of doubt. None the less, it is an attractive theory, and it fits sundry pieces of the jigsaw puzzle which is life into a cohe ent pattern. Though we may not adopt it as the sole explanation of the burden of existence to people of a particular type, we have to admit its plausibility. And whether or no we accept the finer and subtler influences of blood-sugar levels upon our reactions to our surroundings, we must believe that big alterations of those

levels affect, temporarily at any rate, the *persona* we present to the world. Think of the diabetic, instanced above, who, as the result of an overdose of insulin, became "fighting drunk".

THE GONADS

We have taken it almost as granted that sex determines personality, i.e. we have assumed that women as a whole differ in character from men. And we have stated that sex depends on the possession of a definite type of chromosome. If there are two X chromosomes in the ovum it will develop into a girl, and if there is an X and a Y into a boy.

It is not so simple as that. The chromosome pattern may have its impress eradicated in various ways. We have mentioned one or two. (i) We have seen that by treating frog spawn in some abnormal manner before it is fertilised results in eggs which, though they have the XX pattern, develop into males against the rule, and further that these males, even in the spermatozoa they produce, have the XX pattern, for, when crossed with a normal female their offspring are *all* females. It does not so much matter what the fundamental nature is, but the way circumstances allow it to express itself. (ii) The sex chromosomes may set the stage for masculinity or femininity, but the numerical proportion of the other chromosomes to them may upset the expression. (iii) Similarly, later, in the development of the animal, the endocrine organs may either stimulate—or fail to stimulate—or may even distort the expression of sex both in its primary manifestations or its secondary. (iv) Finally, in man, the sociological milieu, psychological surroundings, relations to parents, etc., may distort the sexual personality even though the anatomical structures are completely normal.

Results similar to (i) and (ii) above are unlikely in human affairs. There is no evidence that our numbers of chromosomes get out of hand as they do in the fruit fly. We have 48 against the fruit fly's 8, and there is not much chance (or hope?) of doubling the number. (Incidentally, it would be interesting to know whether pygmies have 48 chromosomes or only 24.) But we have seen that the third possibility is not only a possibility in man but happens not infrequently. The pituitary body may be over-active, with the result that both the primary and secondary sex characteristics are early and over-developed. Or there is under-activity, and the person is under-developed in both

primary and secondary sex characteristics. Again, there may be a disturbance of the functions of the cortex of the suprarenal bodies. This results usually in a hypermasculinisation of the person already male and in a move towards masculinisation (virilism) on the part of the person who is morphologically and probably chromosomally female. There are, too, instances of a feminisation of people who started life and functioned as males, as a result of disturbance of functions of the suprarenal cortex. The effect is seen both in the primary and the secondary sex characteristics. Not only, for example, does the female become pseudohermaphroditic, but the voice, hair distribution and muscular development become more male than female.

Finally there is the psychological influence of environment which may overlay the influence of the morphology of the individual. A "fixation" on the parent of the opposite sex may result in a feminisation in the boy and a masculinisation in the girl, quite in contradiction to the influence of their respective gonads, so that there is a conflict between a person's psychology and physiology. Homosexual males are capable of begetting offspring—e.g., Oscar Wilde was a father of two sons; and homosexual women have produced families.

In considering, therefore, the influence of the physical make-up upon personality and its possible inevitability, we have to remember that innate trends may be thwarted by external influences—"Nature" be thwarted by "nurture" or by accident. It is surely, at times, accidental in the fruit fly and other animals of that type, that a chromosome loses its position in the chromosomal ballet; so, too, it may be accidental that the pituitary is over- or under-active (though doubtless hereditary factors are also involved), or that the suprarenal cortex catastrophically misbehaves. And, in the psychological field, where, at present, we are all so ignorant, it is largely accident whether our children develop normally or abnormally. Wise handling, satisfactory nurture, will enable nature to express itself untrammelled. As we shall see, treatment by extracts of the sex glands, however much they may alter physiological phenomena, are disappointing when applied in the psychological field. You cannot turn a homosexual into a heterosexual by injecting the supposedly appropriate sex hormone.

With which rather long prologue we may as well plunge into the effects of the internal secretions of the gonads upon the expression of sex characteristics. These can be, as indicated

above, divided into two types: the primary and the secondary. By primary characteristics we mean, if we speak morphologically, the possession of genital organs, and if physiologically and psychologically, the capacity for begetting or conceiving offspring. By secondary characteristics we mean, speaking morphologically, the male's possessing greater size, strong muscles, broad chest, undeveloped breasts and narrow hips, a deep voice and male distribution of hair on the scalp, cheeks, lips, chin and neck and body, and the female's possessing developed breasts, broad hips, special distribution of fat about the body, a soprano or contralto voice and female distribution of hair on head and body. Psychologically speaking we mean by secondary sexual characteristics initiative, forcefulness, dominance, extraversion in the male, and conservatism, timidity, submissiveness and introversion in the female—though, Heaven knows, there are many who would challenge such psychological characteristics, and indeed deny any marked fundamental psychological differences between the sexes. They would say that the apparent differences are not fundamental, but due to our present stage of civilisation. One recent book by a woman on women maintains that most of the disabilities of womankind have been forced by mankind upon her by superior strength in revenge for the woman's greater sexual capacity! We shall probably not know whether there are any characteristic psychological differences between the sexes till the Russian experiment of complete equality has been in being for many decades, though to a physiologist, speaking from an armchair, it seems probable that there are.

That the gonads influence physical development and either in a primary or secondary way the psychology, or personality, has been known for centuries. It is a commonplace of observation; of experiments upon animals; of the results of accident, disease or wanton cruelty in man. Every parent and every school teacher knows (or should know) that a child's character changes remarkably at puberty. In a boys' school it is the writer's experience as boy, prefect, and master that the age of puberty is the time when boys are most aggressive, irrepressible and difficult (though amusing) to manage. Novelists tell a similar story; see Meredith's *Richard Feverel*, and more ephemeral books, such as *The Fifth Form at St. Dominic's*, *David Blaize* and *The Loom of Youth*. Doubtless the same is true of girls. We had better get down to the objective evidence of the influences wielded by the gonads.

They themselves are mainly under the control of the anterior lobe of the pituitary which apparently decides when they are to "come of age" and to influence the development of the secondary sexual characteristics. None the less, they begin to wield some influence even before birth. This is shown by the appearance of the "free-martin" heifer among twin calves. As said above, if twin calves share the same or parts of the same placenta in the cow's uterus (so that the embryo calves share the same apparatus for absorption from the maternal blood), and one is a male and the other a female, the female will be stamped for life with such strongly marked male characteristics that she is useless in agriculture. The explanation usually given is that the male hormone is prepotent over the female hormone, or at any rate gets in its work earlier than the female, and so pushes the secondary sexual characteristics of the twin female over on to the male side. Some of the blood which circulates in the male calf passes by way of the placenta into the female calf's circulation. This does not happen in twinning when the circulations of the two fœtal animals are not interconnected in the placenta. (Possibly the male hormone is so prepotent because it has to fight female hormones slipping through from the maternal blood. It is often observed that the breasts of newborn babies of either sex are enlarged and can secrete a fluid called "witch's milk". The explanation of this is that there is a hormone circulating in the maternal blood to regulate the development of the mother's breasts and that some slips into the fœtal blood and so develops the breasts of the fœtus.)

The gonads, however, remain quiescent as the rule till somewhere round 13 or 14, and then, doubtless under the influence of the anterior lobe of the pituitary, begin to develop. With this development they, in their turn, secrete into the blood hormones which start the development of both primary and secondary sexual characteristics till they reach adult size and function. The male gonads enlarge and begin to produce ripe, motile spermatozoa capable of fertilising a mature ovum; the penis grows in size; hair appears on the pubes and under the armpits and on the face; the characteristic male contours of thighs, chest and neck develop and the voice breaks. As said above, the personality changes, often astonishingly, and settles down into unexpected shapes. All these changes do not go on *pari passu*. Usually the growth of hair on the pubes is the first sign (whence the term puberty) and the psychological changes are the last

to occur. Whereas the voice may break around fourteen to fifteen years of age, the changes in thorax may be as late as eighteen or nineteen, and the change in character not complete till twenty-five (if then!). Sex potency, unfortunately, precedes full growth in animals and man: in man, indeed, by as many as seven years or more.

A similar story can be told of girls. Somewhat earlier than in the boy similar changes begin. Her ovaries produce one ripe ovum per month, and as these are not, in civilised life, fertilised and so are incapable of settling in the uterus, the periods begin. Meanwhile the external genitalia enlarge. So do the vagina and uterus. Secondary changes appear in the growth of the hair in a typical distribution on the pubes and also under the armpits; the breasts enlarge; the pelvis broadens, and by a characteristic disposition of fat under the skin the body takes on definitely feminine contours. The voice is more vibrant and rich, but does not alter in pitch.

There is no doubt that these changes in male and female are the result of increased secretion into the blood-stream of the sex hormones.

THE MALE GONADS

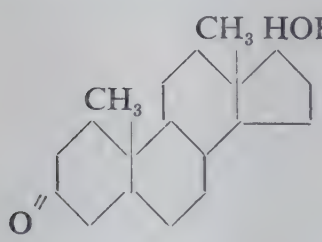
In the male gonads two types of cells are seen: those that give rise to or develop into spermatozoa and those situate in the interstices between the spermatogenic tubules. These cells, called on account of their position the interstitial cells, are doubtless responsible for the manufacture of the hormone or hormones controlling sex development and activities. Thus they are manifest in large amounts long before the sex cells mature; they are present, too, in undiminished numbers in the undescended testicle. For the sex cells to mature it is essential that the testicles migrate from the abdominal cavity into the scrotum. This they do in human beings before birth, but in some animals they descend only at the breeding season, to retire into the abdominal cavity when that time is over.

Now it is frequently found that when they fail to descend in man there is no sign, other than this failure, of a lack of masculinity. The secondary sexual characteristics—deep voice, muscular development, masculine contour and distribution of hair on the face and body—are fully developed. The primary characteristics may be normal also. The man may consummate union, but he cannot beget offspring.

In undescended testes it is found that these interstitial cells are fully developed, whereas the seminiferous tubules are abnormal and contain no mature spermatozoa. This suggests that the interstitial cells manufacture the hormones which control the development and activity of primary and secondary sexual characteristics.

Experiment has verified this. If the ducts leading from the testes be tied in a mature animal, taking care not to interfere with the blood and nervous supply, the tubules degenerate, whereas the interstitial cells remain normal and even hypertrophy. Such an animal retains all his sexual marks and capacities save that of begetting offspring. Indeed, in an elderly animal such an operation results in renewed vigour in all directions and is the basis of "rejuvenating" operations upon man.

In recent times it has been found possible to extract active principles from the testes of animals, to obtain them in crystalline form, to assign a chemical formula to them and to synthesise them in the laboratory. It is probable that the active principles secreted is testosterone. This is closely related to sundry other chemical substances which have marked action on the body: e.g. the female hormones, the suprarenal cortex hormone, vitamin D, the substance which decides where an egg will start development, and two powerful alkaloids which affect the heart. Testosterone in the form of its proprionate is on the market and is used among other things for promoting the descent of an undescended testis. Its activity is measured by the effect it has upon the secondary sexual characteristics of animals, notably in the promotion of the growth of the comb in a castrated cockerel.



One odd things is that while this substance is not secreted in the urine of animals it is in that of man, but in a slightly modified form, viz. androsterone. Only a small amount is secreted in earlier years, but at the time of puberty the amount rises remarkably and is retained at a high level till senility sets in.

Injected into the male, it seems to increase, for a time, the production of spermatozoa, but when continued for a long time, or given in massive amounts, its effect appears to be the repression of spermatogenesis—i.e. fewer spermatozoa are produced. This

has been explained by assuming a depression of the secretory activity of the anterior lobe of the pituitary to take place when there is an excess of the male hormone in the blood.

All this evidence goes to show that the male gonads, and in them the interstitial cells, produce hormones which have a marked influence in promoting and maintaining the development of both primary and secondary sex characteristics. With these characteristics go psychological characteristics. The gonads influence personality.

This is almost a commonplace of observation. In agriculture, removal of the testes transforms a fiery bull into a patient ox. Castration of a cockerel is followed by a rather maternal solicitude for baby chicks. Indeed, this is said to be used in Texas as a way of defending young broods of chickens from the unwelcome attacks of hawks. Cockerels in whom *the spurs have developed* are castrated and then put in charge of young incubator chicks. Not only do they "mother" the chicks, but are armed with a male weapon of defence and offence against birds of prey.

In the laboratory experiment has shown the same. Removal of the testes in a rat alters its activities and demeanour. Implantation of a testis into a female guinea-pig from which the ovaries had been removed caused it to "masculinise" in activities and character. Crowing is a secondary sex characteristic of cockerels, and begins with "puberty". Baby chicks with the down still on them can be induced to crow (but with the voice of a canary) by the injection of the appropriate male hormone.

In man the removal of the testis artificially has been practised since the dawn of history. Such castrates were used as wards of harems. In choirs and places where they sing, the fact that castration prevents the development of a tenor or bass voice has been used to preserve the high-pitched voice of boy sopranos. It is said, but I hesitate in believing it, that this monstrous practice was given up in the Papal choir in 1870 only.

Apart from the change in physical development—lack of calcium in the rather elongated bones, flabbiness of muscular tone, low blood-pressure, etc.—there is a change in the psychological development. The eunuch lacks initiative and stamina; he is a "lone-wolf", retiring, introverted and work-shy, though sometimes the state frees the intellect from the diversions and distractions of sex. A careful examination of the reactions of 20 Chinese eunuchs in Pekin left behind after the revolution

showed them to be introspective, to talk intelligently, but never to volunteer information, so that they appear stupid, to be methodical but with no genuine evidence of purposefulness, and cold and impassive in the face of dire poverty. They were moody and indulged in ugly temper and perverted sex practices.

Now how far these changes are directly due to the loss of male hormones is uncertain. They may be secondary results due to social regard or rather the lack of it. The world has a deep-seated admiration for sexual potency, and in most circles it is an insult to call a man a eunuch. To be childless and to have lost the capacity for begetting children induces a sense of frustration, so that many of the psychological characteristics of the eunuch may be due not so much to the lack of male hormones as to his reactions to the despite in which the world holds him. None the less, that some of these changes are directly related to lack of the hormones is certain from the results of injecting testosterone proprionate into the eunuchoid person. Apart from the physical and physiological changes which can be guessed from the above account the "subjects become capable of and have the initiative to do much more work, both mental and physical. Their interest and proficiency in games that involve muscular co-ordination and physical stamina increase. Finally, to be emphasised is the loss of effeminate characteristics. Whereas before treatment the patients tend to run away from arguments and physical combat, after treatment they often welcome opportunities to demonstrate their prowess."[1] Whether effeminacy be characterised by lack of aggressiveness, physical and mental, or no, there is evidence here of the personality's being chemically conditioned. Lack of testosterone: passivity, apathy, defeatism. Testosterone: activity, initiative, aggression.

THE FEMALE GONADS

The male gonads have but two main functions to carry out: (i) to make mature and active spermatozoa, and (ii) to develop the sex characteristics, morphological, physiological and psychological. (Perhaps we should interchange the order of (i) and (ii).) The female gonads have at least two more functions. Not only must they preside over the production of ripe ova and over the functions of the organs which make fertilisation of those ova possible, but they also regulate and control the settling down of the fertilised ovum in the uterus and its development

[1] Hoskins, *Endocrinology*, p. 219.

till birth. They also prepare the mammary glands for secretion of milk. It will be best to give a brief sketch of the cycle of operations in the ovary.

The ovaries are small bean-shaped organs, about 1½ inches long and 1 inch across, situate symmetrically on the back wall of the upper part of the pelvis. Each consists of a cortex and a medulla, but whereas the medulla consists mainly of contorted blood-vessels and connective tissue, the cortex contains a broad band of round cells destined to grow up into the mature ova together with similar cells which minister to the ova's needs and connective tissue. This account is true of the ovaries from before birth to the time of puberty.

At puberty one of the immature ova—there are a huge number of them, forty thousand or more—is surrounded with a cordon of ministering cells, forming an envelope around it. This rapidly enlarges. The walls double. A space may appear between the walls filled with fluid. The whole structure grows and grows, bulging the surface of the ovary. When mature the relatively large ovum, cradled in a mass of ministering cells, stands on a pedestal of more cells within a spheroid partially filled with fluid, but lined with more of these ministering cells. Meanwhile the ovum has been maturing. It may have already cast out the polar bodies in some animals; in others, and probably in man, this takes place later. It will have laid up yolk material for its nutrition and surrounded itself with a clear and relatively thick membrane, the zona pellucida. Probably there is some tension within the follicle, as the structure containing the ovum is called. At any rate, when it is mature it bursts and liberates the now ripe ovum into the fluid in the abdominal cavity. Here it floats till it comes within the influence of the Fallopian tubes. Into one or other it passes—occasions have been known when an ovum discharged by the right ovary has found its way down the left Fallopian tube—and it passes somewhat slowly down till it enters the uterus. Whether it can settle in the uterus depends partly upon whether it has been fertilised or not and partly on secretions of the ovaries. It should have been fertilised in its passage down the Fallopian tubes by invading spermatozoa which have swum up from the vagina, through the uterus and then up the tubes, passing in a contrary direction to the gentle current down them caused by their ciliated lining. If the ovum is fertilised it begins actively to divide at once and may have reached the "mulberry" stage by the time it enters the uterus. It ought to settle in the

mucous membrane between the entrances of the two Fallopian tubes. It is endowed with ferments which enable it to eat its way into that mucous membrane which reconstitutes itself over the group of cells which now form the embryo, the newly-begun separate individual.

But before it can burrow into the mucous membrane of the uterus the latter must be prepared for it. It must be deepened and more richly supplied with glands and blood-vessels. The control of this is due to the ovaries, and we must go back to consideration of these. When the follicle has burst, the thin walls which burst come together again and reunite. Then proceeds an invasion inwards from the outer walls of the follicle of large oval cells forming columns within and supplied richly with loops of blood-vessels which follow the invasion by the advancing columns. As these invading cells contain a yellow wax-like constituent, and as the body ultimately becomes as large as a culinary pea and is easily visible and *yellow* to the naked eye, it is called a *corpus luteum*. The process of forming yellow bodies is called luteinisation.

Now the process of luteinisation will have gone some distance before the fertilised and dividing ovum reaches the uterus, and it is almost certain that the yellow body is a *new endocrine organ* secreting a substance which prepares the uterus for implantation of the fertilised ovum. If (in an animal) the *corpora lutea* are destroyed after insemination, the ova never "fixate", i.e. they do not settle down in the uterus, whereas any other operation as severe or severer in the abdominal cavity does not check fixation.

Should the ovum not settle down but be lost, the work of the yellow body has been in vain, and after a fortnight's ascendancy it proceeds to degenerate, and by the end of two months it is no more save that a scar marks the surface of the ovary where it was but is not. It had prepared the walls of the uterus to no avail, and the increased layers of these slough off and are extruded to the outer world in that process known as menstruation. Ovulation (i.e. the bursting of a follicle in the ovary and the passage of the ovum into the body cavity) precedes menstruation by some ten to fourteen days. Therefore, the time when fertilisation is most likely to be achieved is roughly half-way through the menstrual cycle, not immediately before or after as used to be thought. It is interesting to note that the orthodox Jewish hygienic code interdicts marital relations in the seven days following menstruation, thus ensuring that it should take place when fertility is most likely to result.

Should the ovum fixate satisfactorily the yellow body continues to enlarge for some months, producing a sizeable new organ something like a marrowfat pea embedded in the body of the ovary. It reaches its maximum around the fifth or sixth month and then slowly regresses, though at full term it is still a conspicuous structure.

This somewhat "factual" discussion of the history of ovulation, nidation and the growth and decay of the corpus luteum has been necessary to lead up to the twofold influence the ovaries wield over sex manifestations and possibly over the personality of a woman. There are at least two hormones or sets of hormones secreted by the ovaries. The first governs the development of the primary and secondary sex characteristics, including ovulation, and the second the processes of nidation and gestation. Should the first hormone or set of hormones be deficient, the secondary sex characteristics do not appear and mature ova are not formed. Ovulation is impossible. The second set of hormones are concerned with preparing the uterus for the reception of a fertilised ovum, and for its care and development into a full-term baby during gestation. They also control the development of the breasts, making them ready to secrete milk on the birth of the child.

And these two sets of hormones are antagonistic. During pregnancy ovulation is suppressed, and experiment shows that this suppression is due to the presence of a corpus luteum in the ovary. If, as said above, the corpus luteum be removed in animals, the ova released at the previous ovulation never settle down in the uterus. If they be removed after nidation the animals abort. If extracts of normal ovaries be injected into a pregnant animal that animal aborts. If, as sometimes happens in cows, the corpus luteum persists after the birth of a calf, that cow does not ovulate and so remains infertile unless the veterinary surgeon manages to disrupt it. Then the sexual cycle of the cow is resumed. There is, then, a conflict between two sets of hormones both arising from the ovaries. How far is that conflict represented in personality?

That there are changes in emotional reactions at the onset of puberty is a commonplace. That these are largely the result of hormones from the gonads is fairly certain. In animals the removal of the ovaries results in their remaining sexually neutral throughout life. They are never attracted to, and never attract, the male. Destruction of the ovaries in early life in the human being has rarely been investigated, but what accounts there are

suggest an exactly similar set of results—lack of development of the sex characteristics, physical and psychological. Under-activity of the ovaries as the result of deficiency of the pituitary hormones has frequently been observed. The physical results are what might be expected: under-development of the primary and secondary sex characteristics, delay or absence of the signs of puberty, but if the sexual cycle manifests itself there may be difficult "periods" and low or absent fertility. But, according to Hoskins: "Despite the genital inadequacy, the subjects may attain to a substantial degree of adult psychological maturity. They are often quite feminine in attitude and general appearance, and may be genuinely and romantically interested in the opposite sex."[1] We take it that though the expected reaction of indifference to the opposite sex may occur, this is not invariably so, and that a woman incapacitated physically for a full sex life may, none the less, be psychologically well equipped for it.

Somewhere around the age of 45 the ovary begins to produce less and less of the sex hormones and we have the onset of the menopause. Now it is the fashion to ascribe anything which happens after this time in a woman to the menopause—e.g. the aches and pains, the muscular disabilities, the insomnia which may be merely due to the advance of time. A few are barely aware of the transition. More experience only moderate discomfort. Some show irritability, difficulty in concentration, suffer from headache, depression and insomnia, and may ultimately pass over into a state of melancholia, called, from the time of its onset "involutional melancholia". In human beings the sympathetic nervous system appears to be more unstable than is normal. At the slightest disturbance, or even on no external stimulus, there is flushing of the skin and intense perspiration. In animals Hoskins has shown that there is hypersensitivity to adrenalin after the removal of the ovaries. There is sympathicotonia (see above p. 55). It is reasonable to assume from "flushing" as a symptom of the menopause that this applies to human beings as well. If so the *signs* of emotional reactions will be exaggerated.

Some clinical observers think that there is a move towards virilism with a masculinisation of the disposition leading even to arrogance and self-sufficiency. As the suprarenal cortex is said to hypertrophy at this time, there are grounds for relating this masculinisation to the influence of that tissue rather than directly to the loss of gonadal hormones.

[1] *Endocrinology*, p. 233.

We have to be careful not to assume too much in discussing the effect of the wane of ovarian hormones on the personality. It is true that changes have been observed. It is true that irritability, arrogance, self-sufficiency, or, in contrast, melancholia, may occur at the same time as the menopause. This does not prove that they are conditioned by the loss of the ovarian hormones. They may have been conditioned by mistaken upbringing. Women are taught to expect trouble at the menopause. They imagine (despite the career of Ninon de l'Enclos) that they will no longer be attractive to men. They think that their sexual life will decline, and they commiserate with themselves in their unhappy lot. And the novelist capitalises this—either in tragedy or comedy; and the cunning operatic librettist and film scenario writer exploit it. Generally the world (and possibly the flesh and the devil) unite to tell her that she is down and out. Is it astonishing that the menopause is a difficult time for women? Might this not be due to faulty education as much as to lack of hormones? We hardly know as yet, nor shall we know with certainty till the cheap novel and the sentimentally erotic film and the half-witted misinformation concerning sex affairs whispered behind hands are things of the past.

Nor does the production of an artificial menopause help us much. Sometimes the ovaries—all, or in part—have to be surgically removed as the result of disease. Much the same results occur as in the normal menopause. There is the instability of the sympathetic nervous system and there are physical signs of masculinisation. There may be psychological masculinisation as well. One such woman maintained to the writer that her vocabulary had been distinctly masculinised and that she could now swear with ease and fluency. And some workers have given a sufficiently gloomy picture. "Deprivation of the ovarian hormones during the normal reproductive years results in a peculiar quality of nervous tension and irritability. An insistently expressed egoism is the keynote of the hypogonad character. Coupled with, and dependent on, this is an active resentment towards a world that is but inadequately mindful of the patient's many excellencies. Hyperemotionalism and self-pity are united with an attitude of acid criticism of environmental conditions that are always unsatisfactory. The psychological study of the average woman suffering from ovarian insufficiency would be profitable though scarcely a pleasant task."

There speaks the misogynist, basing his observations on the

contemplation of a few abnormal women. It is perfectly true that such people can be met in most walks of life and among males as well as among females, and, while the description accurately fits some whom we have met, it is impossible as yet to say how far their disposition has been chemically determined and how far psychologically. Is it directly due to the lack of the hormone or secondarily to the inferiority, felt or imagined, induced by the hypogonadism? And is the misogyny of the quotation above determined chemically or psychologically?

One most interesting set of observations there is on the relation of psychology to the tides of the hormones in women. We know that the ovary forms two antagonistic groups of hormones: (i) those of the general mass of the ovary, called "oestrin"[1] inclusively, and (ii) those of the corpora lutea, called "progestin". In the sexual cycle from menstruation to ovulation "oestrin" is in the ascendant, and from ovulation to just before menstruation "progestin" has the upper hand. We should expect the oestrin to encourage the seeking of, or at least the submission to, a mate, and the progestin to promote a self-protection which, of course, would entail the protection of the fertilised ovum, its nidation and subsequent growth.

Two workers, Benedek and Rubenstein, quoted by Hoskins, investigated the parallel changes in physical signs and psychological states in a group of women who were undergoing psychoanalysis. One investigator kept charts of the physical signs (temperature, etc.), and the other made an elaborate analysis of the patients' dreams. When the two groups of data were compared there was a significant relation between them, and this was the relation: When the women were under the dominance of oestrin, psychologically they turned to the outside world, and that world was one of relationship to the other sex. During the time when the progestin was beginning to be produced and was antagonising the oestrin there was a brief stage of "more or less flighty irritability". Finally, as the progestin obtained the upper hand the women turned their psychological interest towards themselves with especial concern for their own bodily welfare. The progestin thus apparently not only moulds the physical nature of the body but also the psychology in the direction of conserving the welfare of the impregnated female

[1] Oestrin is here being used to denote the group of oestrogenic hormones, oestrone, oestriol and oestradiol, and progestin the group controlling pregnancy and containing progesterone and pregnandiol.

and the newly-created being during its sojourn within the body. There is thus some evidence, which needs repeating and confirmation, that psychological reactions are influenced by internal secretions—are conditioned chemically.

Probably evidence from the gonads gives the strongest, the most certain grounds, for believing that the endocrine organs are potent in determining our personalities.

CHAPTER IX

Recapitulation and Coda

In the preceding chapters we have attempted to show how physical inheritance influences personality, which has been defined as "that quality or assemblage of qualities which makes a person what he is as distinct from other persons". And there can be little doubt that personality, so defined, is largely determined by physical make-up. The question remains: Is it wholly so determined and is there any escape from the materialist view that we are what we are simply as the result of uncontrollable forces operating on and through a mechanism whose form and structure are the results of inheritance? To put concrete examples: Is the writing of any Penguin book as inevitable as the return of Halley's comet or as the eclipses of the sun by the moon? Could you and I have abstained from writing a poem like "Paradise Lost" for any other reason than that which causes us to abstain from leaping over St. Paul's Cathedral? Was, indeed, the production of this fragmentary account of the physical basis of personality determined down to the last full stop? Could I not have inserted a necessary, or unnecessary, comma?

As a matter of fact this does not logically concern us. We are interested in the relation of personality to the body we inherit. How far is our personality determined by that body? Wholly or in part? It would be well to collect the evidence given in the preceding chapters into a coherent whole. It is as follows:

Personality may be determined by (*a*) physical endowment and (*b*) environment and nurture. Our interest lies more in physical endowment: whether we are short or tall; fat, like Falstaff, or thin, like Casca, and how far this physical endowment influences personality.

Now inheritance controls physical endowment. Identical twins, i.e. twins who have arisen from the separation of a

fertilised ovum into two, probably at the first division, have shown not only an extraordinary physical likeness but a likeness in psychological make-up. For example, they have got into trouble with the authorities at much the same time and for much the same type of misbehaviour. If this is not the result of nurture—which is difficult though not impossible to believe—it looks as though inheritance plays a predominant part in our make-up. We know that colour-blindness is inherited according to definite rules, and so is hæmophilia, and these certainly influence personality.

Inheritance of physical make-up can be studied only via the cell, for each one of us began as a single cell, and all of our potential characteristics, our long or short noses, our heads of hair, our height and breadth, our colour vision, our susceptibility to disease, the size and balance of our nervous system and the capacities of our endocrine organs, must have been carried in that one cell. In that cell the nucleus is paramount.

This cell nucleus is the result of the fusion of two nuclei: that of the sperm cell arising from the body of the male parent and that of the virgin ovum arising from the body of the female. As our characteristics are inherited from both our parents and we appear to be, on superficial and deeper examination, a mosaic of parental (and perhaps grand- or great-grand-parental) characters, those handed on from the male parent must have been transmitted mainly by the nucleus of the single sperm cell, those from the female by the nucleus of the ovum.

In the nucleus there is a stainable substance called chromatin, invisible in the living cell under the microscope except (i) when the cell is dying, and (ii) when it is about to divide to make two daughter cells. Then this chromatin breaks up into short thread-like objects called chromosomes. These chromosomes behave in a very constant way. Each plant or animal has its own specific number of chromosomes, the number in the body cells being double that in the sex cells, so that when the sex cells are formed, the number of chromosomes is halved, and when a new individual is generated by the fusion of two sex cells the original number is reconstituted. Half of the chromosomes in the newly-formed individual come from the sperm and half from the ovum, i.e. one half originates from the male parent and one half from the female. Moreover, if a chromosome have a peculiarity (i.e. is short or long, straight or bent or hooked) this peculiarity reappears every time the cell divides. So, though a

chromosome apparently loses its identity when fused with the others into a resting nucleus, it preserves that identity, though masked, and that identity is rediscovered when the nucleus again begins to divide. Here, in the chromosomes, is a probable machine for handing on the hereditary potentialities. We have only to assume that each chromosome carries a definite number of characteristics to picture a mode by which we receive and hand on those physical characteristics which give us our physical individuality.

Such a hypothesis is confirmed by all the facts discovered in the last thirty years or so by observations made in controlled experiments on heredity. Naturally the experiments were made on organisms that reproduce themselves much more rapidly than man, notably on the fruit fly by Morgan, on moths, on maize, on pigs, on peas and a number of plants and animals by a host of experimenters. This work was based on forgotten discoveries made half-way through last century by the Abbé Mendel, and rediscovered at the turn of that century. Mendel's work was upon the culinary pea, but in the opening years of this century the facts of inheritance discovered by him were shown to be applicable not only to plants but to animals of all sorts, including man. There is little doubt that the inheritance of unit characters in man follows the same rules as that in culinary peas, evening primroses, sweet peas, Indian corn, daturas, primulas, moths, butterflies, fruit flies, beetles, grasshoppers, mice, rats, chickens, cats, dogs, and guinea-pigs, to mention some, but by no means all, of the plants and animals investigated.

When a cell divides to give rise to two cells the chromosomes behave in a curious way. They set to partners, they disjoin again, they perform a complicated dance, divide lengthwise into two and then segregate into two groups and form two star-like figures which condense into the new nuclei. It was Sutton who first pointed out that the Mendelian characters are dealt out in a way precisely similar to that in which the chromosomes are partitioned between cells. So that it is no wild postulate to assume that those Mendelian characters are carried by the chromosomes. That is, indeed, the modern assumption, and it must be admitted that the manifold observations made in a multitude of laboratories, more particularly Morgan's, on a large number of plants and animals support that assumption. Not only is this widely held by geneticists, but they can and do assign in some animals definite characteristics, not merely to a particular chromosome,

but to a point upon that chromosome. In fact, the Mendelians have mapped the chromosomes of the fruit fly fairly completely. They postulate that each unit character (blue-eyedness, for example, in man) is carried by a unit structure, a "gene", and they can place in a few animals and plants each known gene in a particular chromosome. The chromosomes form the physical basis of inheritance.

Doubtless sex is determined by the chromosomes. There are among the chromosomes one couple that determine sex. All the chromosomes in a body cell are paired with this one exception. Sometimes one of them is smaller than the other, sometimes of different shape, sometimes altogether missing. As the "sex" chromosomes are dealt out in forming the sex cells and recombined on fertilisation, so is the sex of the resulting new animal fixed.

In man and other mammals the two sex chromosomes are o different sizes. If the new-formed animal receive two of equa size it becomes a female; if two of different sizes it becomes male. Man is, in a way, the dwarf of a woman. Thus sex i determined by the chromosomes (though its expression may b modified by later accidents), and if sex has any influence o personality—and most people believe that it has—personality in so far, is determined by chromosome make-up. This is th first and practically ineluctable piece of evidence that ou personalities are determined by our chromosomes. The se ratio (practically 50 : 50) is what you might expect from Me delian studies when a pure breed is crossed with a mono-hybri Sex behaves like a Mendelian character. And since it is u doubtedly carried by chromosomes it appears certain that Mendelian characters are carried by chromosomes.

Now at first sight Mendelian characteristics (blue-eyedne lack of a capacity to sunburn, six-fingeredness) appear somewh superficial. It was at one time difficult to believe that our heritance is through and through Mendelian. However, sex fundamental enough. It is no frill or appendage or excresce of the body, but permeates it in its entirety. And it is n believed that all our inheritance is determined in a Mendel way: its continuous nature being due to the large numbers characters and to their possible blending in their effects. mathematicians have reconciled the Mendelians and the metricians.

Consequently our next step must be to assume that the

shape and capacity of all the organs of the body are determined by the "genes" we inherit from our parents, grandparents, and so on back down the generations. In our consideration of personality we ask what organs demonstrably influence it. Presumably all do in some measure. We can all agree that the colour and sheen of the hair; the texture and tint of the skin; the teeth, the ears, in fact the whole bodily make-up may influence the personality—if not directly, then in a secondary way. But of all organs in the body which certainly may be expected to influence the personality, the nervous system[1] and the endocrine organs stand out as the most important.

This must be so, for they are the organs which are especially concerned in the welding of the body into a functional unity. If they fail, the body cannot be integrated. *It is the nature of the integration of the body which largely determines its character and its individuality.* That psychological integration depends upon physiological integration is undoubted. The thalamus in the brain is the seat of emotional reactions, and these reactions are controlled and guided by the fore-part of the brain. Personality depends upon the amount of dominance of the one by the other. Almost certainly the seeds of that dominance must lie in inherited characters.

Again, the endocrine organs give us examples of undoubted influence of their activity upon the personality. Under-activity of the thyroid produces apathy and dullness of mentality; over-activity, anxiety and fear. Possibly in the endocrine activity of the gonads we see the most striking examples of the influence of physical make-up on the personality. There is, as we have seen, the completest evidence that sex is determined by chromosomal influence, and the gonads in their turn by their internal secretions wield a marked influence upon character.

This recapitulation of the findings of the earlier chapters of this book has been made because the effect produced is cumulative and much greater thus than when the facts are scattered over many pages. This effect is, if I am not mistaken, that our personalities depend on our physical bodies and that each characteristic of those bodies depends upon the genes we inherit. We are what we are because of our inheritance, and are determined down to the last hair in our eyebrows or freckle on the

[1] Adrian actually states that the type of the electric current variations which are the sign manual of the activity of the brain cells varies with the personality of the owner of the brain.

skin. To go further, could we know all the forces operating at any one moment of history we could predict the rest of history from that cross-section in time. In fact, force and matter are everything, and mind, beauty, love and laughter but the spume thrown up by some gigantic mechanism of Fate crashing its way through the seas of Time: materialism rampant, in fact.

I confess there are moments when I feel this conclusion to be inescapable, and can only put up the feeble answer of a character in Aristophanes' Plutus, "I won't be convinced, even if you do convince me." But is the position as bad as all this? Is there no way out? Is there any hope?

> At last I heard a voice upon the slope
> Cry to the summit "Is there any hope?"
> To which an answer peal'd from that high land
> But in a tongue no man could understand;
> And on the glimmering limit far withdrawn
> God made Himself an awful rose of dawn.

That some, even much, of that "assemblage of qualities" which make us what we are is determined by inheritance, I think we must admit; some will say "all".

An attempt to make it seem not all so dreadfully mechanical is to point to the fact that often the expression of our inheritance is influenced by environment.[1] That nurture influences the expression of what we receive by nature no one will deny. The problems remain: How much does nature account for, and how much nurture? Those whose political leanings are towards the Right and who assume that they are where they are by inheritance and inheritance alone, suggest that nature is everything. Those of the Left, who wish to show that the differences between the classes are due to the extra advantages enjoyed by the rich, emphasise the importance of nurture. There can be no doubt that our intelligence quotient as measured by the psychologists is raised by living in a city, and this appears at first glance to put considerable importance upon environment. It must, however, be remembered that the inventors of the intelligence tests are urban and academic folk, and therefore it is likely that the

[1] "We must never lose sight of the fact that a certain gene in a certain genotype determines only the potentialities of the zygote and that in development only some of its potentialities will be realised." Waddington, *An Introduction to Modern Genetics*, 1939, p. 326.

tests are pre-eminently urban and academic, and merely rate those people highly whose predilections are the same as those of the experimenter.[1] Argument from intelligence quotients, though frequently used, in both directions—i.e. in proving the importance of nurture over nature and vice versa—is suspect.

Turning to something less measurable—social and asocial attributes—we have seen above, in the sections on the endocrine organs, that the end results of sub-activity are not always the same. Usually the sub-thyroid person is not a difficult person to get on with—he is too apathetic. At times, however, he becomes asocial in a more positive way, pugnacious, irritable and even sadistic. He is revenging himself, like Hitler, upon society because of his inferiority. It might be argued that in a different environment the aggressive subnormal would have been complacent, and further that if we could alter environment in the right direction, making people more tolerant of misfits, the subnormal would not develop in a vengeful way. (Of course, this has been the direction of development of our penal laws, though they have a long way to go yet. It is not softness of heart or intellect which makes us more gentle to criminals than our forefathers. It is more like soundness of judgment. Something of this saner attitude towards crime must get into our international relations or history will go on repeating itself, as Anatole France suggests it will in *L'Ile des Pingouins*.)

Still, putting part of the blame or praise of what we see in human kind upon nurture rather than nature is no escape from the materialist position. It can be argued that the environment is determined. In fact, it will be argued by those who have "taken up with" dialectic materialism that the rise of the democratic mode of government has provoked a counter-uprising of its antithesis, Fascism, and out of the strife between the two, the new future synthesis of government of the world will arise. If our genes are such that we dislike the influence of alterable environment upon character, we shall be forced to alter environment.

The main opposition to the materialistic position into which we seem to be forced comes from philosophy and religion, but before

[1] For example, the set of intelligence tests used upon the writer contained a section devoted to the meanings of words, and if he had not scored very highly in that section he would have been rated somewhere about the moron level instead of the level of an ordinary adult. Suppose he had been tested on the names of birds!

we look at these there are one or two arguments which must b examined first.

The first is concerned with personality. What do we real mean by it? It is perfectly true we borrowed the O.E.D. definitic of personality and said, "let this be what we mean by perso ality". But as this discussion has shaped itself the writer ha become more and more unhappy about the use of the wor The trouble is that "my personality" will insist on identifyir itself with what I call "myself", "I"—that enduring entity which I have been continuously conscious since I becam conscious. Somehow that entity, whatever it may be, refuses t be equated with the form into which it has been moulded b inheritance and environment. And it seizes on the derivation meaning of the word personality as a plausible reason for tha refusal. For the "persona" is a mask worn by actors in ancie drama, and personality may be merely the outward form im pressed upon the spirit within, the real "I", by inheritance an nurture. We shall return to this later on. The second considera tion is that throughout the argument summarised above w have had to use terms which are imprecise, to make assumptio which may turn out not to correspond with reality and to tak leaps from verifiable facts to theories which are as yet unver fiable. In fact, in other words, we have extrapolated, i.e. e tended the trend of facts beyond the point where facts end an surmise takes their place.

It is the curse of language that no one word can include a the meanings which attach themselves to the idea meant to b represented, a fact seized upon, often unconsciously, by all thos out to make a case—lawyers, philosophers, theologians an demagogues. If we start and build up a logical edifice upon a imprecision, introducing at each stage of the argument oth imprecisions, the final result, though appearing irrefragabl may yet be so unsubstantial that the first assault upon th structure brings it to the ground. That is the history of philosoph and theology, as I see them. Perhaps an analogy, introduce from mathematics, may illustrate what is meant. Argument something like multiplication. Suppose x is taken to repres an idea which it describes by a small amount of imprecisi which may be represented by dx. If we use the idea twice ov in the steps of an argument, the result in logic is x^2, but t result in reality is $(x + dx)^2$, which is $x^2 + 2xdx + d^2x$. N if dx is small, d^2x is negligible and the imprecision is represent

by $2dx$. In other words, the "woolliness" of the result is doubled at least. But suppose the woolliness represented by dx was large, d^2x cannot be neglected and $2dx$ becomes formidable. It may be that an argument based upon the imprecision of language in denoting an idea, when the steps taken are numerous, will bear no relation in the end to things as they are. It is a complaint used against our materialists that they take an abstraction based upon the reactions of matter under our noses, transfer it to the stars and the distant nebulæ, show that this abstraction apparently works there, and bring it back to this earth and try to fix it upon the workings of things, such as human affairs, from which in the first place it could never have been abstracted. Have we in our argument been guilty of such steps in reasoning? That is a question each must answer for himself, though let it be said that we shall almost certainly answer it according to our predilections!

All this is summed up in the phrase coined by H. G. Wells, "the scepticism of the instrument". The instrument is the intellect. It is a fine instrument, but does the use of it inevitably and inexorably lead to truth? The answer is, surely, only if at each stage the deductions are verifiable by experiment, and here, only if the experiment is made by one of unshakable honesty, acumen and rectitude. That is the tragedy of theology and philosophy: deductions are not verifiable by experiment.

I cannot see that this scepticism of the instrument need particularly worry the sceptic. It is true that he should be sceptical of the absolute force of his own deductions, but that is no reason why he should accept the fallible deductions of his opponents. We so often meet that attitude of mind in people. "What? You cannot believe in the findings of your intellectual activities? Then you may as well believe ours as your own." That seems to me not to follow. And, anyhow, I was using the scepticism of the instrument as a possible avenue of escape from the deductions of the materialists into the more genial positions held by philosophers and theologians.

None the less, it seems to me that, despite scepticism of the instrument, the geneticists and physiologists have made out some sort of a case for the possibility—and many would say probability—that the outward shows of character, which we have agreed to dub "personality" are largely, and perhaps wholly, determined by inheritance and nurture.

What are we to make of this? I admit that the materialist position always has roused the deepest antagonism in me since

first I became aware of materialism as a possible philosophy.

Is it to be rejected because it would be so unpleasant were i true? No scientific mind, and I hope no thoughtful person coul accept that avenue of escape for a moment. It is true that man of us reject political beliefs on such disgraceful grounds, e.g Vansittartism and its converse: the perfectibility of the Germa nation. It would be horrible to many of us—the majority of us I think—if materialism were true, but that is no reason fo rejecting the theory out of hand.

Is it to be rejected because no great mind accepts it? Again were that true, which it is not, it would be no sound reason fo rejecting the theory. Besides, there is at least one living philo sopher, surely one of the greatest minds the world has produced who writes: "Everybody acts not only under external compulsio but also in accordance with inner necessity."[1] There is little us in counting noses when debating the tenability of a proposition We need more serious arguments.

There is one argument based on the ground origin of scientifi work, which is the evidence of the senses. "History," Henry For said, "is bunk." To many philosophers science is bunk, an quite reasonably so, though what bunk is needs definition Shakespeare had another way of saying "bunk"—

> "The cloud-capped towers, the gorgeous palaces,
> The solemn temples, the great globe itself,
> Yea, all which it inherit, shall dissolve;
> And, like this insubstantial pageant faded,
> Leave not a rack behind. We are such stuff
> As dreams are made on . . ."

Putting it still another way: the whole of science is based upo the evidence of the five or six senses. This extraordinary fabric o science, which when applied has given us disease-destroyin drugs, high explosives, flight through the air and passage beneat the waves, speech across the oceans and the integration of ma kind and his activities throughout the planet, is raised on th frail ledge of man's special senses. It is an orderly descriptio of the consistent results accruing from the exploration of th data they give us. And we have no logical reason for believi that these data are much more than distortions of the trut In fact, in some respects, supposing for a moment we belie

[1] *The World as I see it* Einstein. The Thinker's Library, No. 79, p.

in the existence of things outside ourselves, we can be sure that what we see does not correspond to reality. Thus greenness corresponds to what the physicist describes as vibrations occurring at so many times per second in a hypothetical medium. There is no likeness between green and millions of vibrations, and no likeness between hardness and a space almost empty except for a number of minute electrons revolving round some tiny proton core. The atom to the physicist is as empty, except for these electrons and the proton, as a cathedral would be if there were nothing in it but a swarm of bees. Matter, whose malignity baffles, impedes, buffets us all the day long, is a thing whose sole attribute to the mathematical physicist is something which corresponds to a set of mathematical equations, things which exist only in the mathematician's mind. Lewis Carroll, if he were alive, would say that matter exists only in the Red King's dream.

When the metaphysicians have finished with matter they have stripped it of all its attributes and left us nothing in which we can believe. A "permanent possibility of sensation", said one physicist years ago, when defining matter. But even that has gone now, for matter can be transformed into radiation and so dissolve into non-matter. Science is based on the experimental method, and as Anatole France's philosopher put it in *Les Sept Femmes de la Barbe-Bleue*, "C'est la défaut de la methode experimentale, employée par ces dames (les fées) que l'experience s'addresse aux sens dont on peut toujours récuser la témoignage." The defect of the experimental method is that it addresses itself to the senses whose witness we can always challenge.

Thus if science is based on the fallible witness of the senses, science is bunk, and there is no need to believe in anything which the microscope and the scalpel, extensions of our power to perceive through the senses, tell us. Chromosomes are bunk, genetics is bunk, and determination based on genetic observations is bunk. That is one answer and a logical answer to the claims of the materialist geneticist. They can be brushed aside with a snort of "stuff and nonsense".

But will such cavalier treatment do? In that crepuscular world inhabited by metaphysicians perhaps yes, but in the ordinary everyday world probably not. The argument would convince no one who did not want to be convinced.

Another argument like unto it is that science deals not with the problem "why" but "how". It collects data and then groups

them in an orderly way, seeing if any convenient shorthand expression will describe the group and its way of going on. The fixed stars appear to gyrate round us once in twenty-three hours and odd minutes. Taking any one time at night throughout the year the stars appear to make one rotation round us per year. The planets pursue a more erratic course in the sky. Their motions are not fixed in relation to the stars. They wander—hence their name—and loop the loop against the background of fixed stars. Our moon behaves in an engaging way, and, if there were not method in it, we might call it lunatic. The scientist produces order out of these disorderly goings on by postulating that the earth and the planets revolve at different distances round the sun, which is one of the stars, and the moon revolves around us. But he does not say that the planets *are* revolving round the sun; merely that the behaviour of the planets is best described by saying it is "as if" they were solid bodies revolving round the sun. And then looking at those planets and their imagined orbits round the sun and the imagined orbit of the moon round the earth, he says they behave towards one another "as if" there were a force pulling them towards each other, which varies as the product of their masses and inversely as the square of the distance between them. The stars, sun, moon and planets behave "as if" there were this force between them, not "because" there is this force between them. "As if" is "how", and "because" answers "why". The scientist deals merely with "how" and not with "why".

Similarly hundreds of data of fossil remains of plants and animals are collected; data of the anatomical structure and embryology of modern plants and animals are investigated; data of their distribution over the face of the globe, to match the temporal distribution as shown by geology, are gathered together and all these manifold data are briefly summed up by saying (making order come out of chaos) that they are "as if" living organisms had evolved from one original stock. The theory of evolution does not say that they *are* so evolved, but appear "as if" evolved. To say anything more is bad science; it is traversing the boundary between science and metaphysics.

". . . The business of scientists is to tell us *how* things happen. They describe, but they never explain, far less explain away. For no one has the least idea what anything *is* or why it ever arrives—though we may know a lot about how it survived. If

scientists cannot answer the question *why* no one else can. In so far as we try to do so we are merely being amateur scientists and intellectuals barking up the wrong tree. Religion is not an intellectual search nor a rational scheme. It is an *experience*—or nothing worth. Science is an investigation of the Divine Appearances. Religion is an experience of the Divine—after which we are entitled to utter the words IT IS with joy, and to comprehend the profoundest words in the language—I AM THAT I AM. That is why there is no conflict between science and religion . . ."

JOHN STEWART COLLIS. *Time and Tide*, 6th March, 1943.

Applying this to our problem, we say that the data of the geneticist can be summed up by saying that inheritance behaves "as if"—not "because"—there are particular characters postulated by Mendel; "as if" there are genes on the chromosomes. To say that the hereditary potentialities are carried and handed on by the genes is bad science. So, to complete the argument in our problem, you say "if you do not wish to believe that your personality is determined by your genes you need not. If you carry over the hypothesis of science into the world of your beliefs you take a step unjustified either by science or metaphysics."

That argument may give comfort to some. It may satisfy the sceptical scientist, but I fear that it will be rejected by most people as playing with words—intellectual amusement, perhaps, but not sound sense.

And as we have mentioned common sense we may as well look at the matter from the point of view of a method of philosophy which had a brief period of efflorescence at the turn of the century: pragmatism. Probably pragmatism is the philosophy usually unconsciously held by the scientific worker. It defines truth as that which works. That, of course, is the commonsense attitude about truth. And it is how presumably we achieved an idea of truth. A theory, a belief, which works for us, is true.

Can we apply this criterion to the theories of genetics? Almost certainly. It works not to marry into a family where there is hæmophilia. If you want your children all to have blue eyes you should not marry a brown-eyed woman. But if we push the view to its extremes: that we are all conditioned by our inheritance, that force and matter have us in their grip, that we are all predestined to good or ill by our chromosomal make-up and our environment, and that while we may be able to modify environ-

ment we can do nothing against the power of heredity, does still work? Most people shrink from such a belief and man would deny that it works. They would say that any societ dominated by materialism rapidly meets its doom. Of cours religion has denounced this view from the beginning, but histor is not far behind religion in discrediting it, and psychology wi have little of it. Moreover, if anywhere there be an incarnatio of materialist doctrine it is in Hitlerism, and it works so badl for mankind that it arrays the rest of the world against it. Th practical application of materialism does not work, as eve the most materialistic-minded are being forced to see, and it odd, but reassuring, to hear across the battlefields of the wor and through the noise of mechanical warfare a still small voic whether from Galilee or the Bô tree or from within it does n matter, telling us that force is not all. Materialism does not wor but that is not to say that it is not true, for most of us ha proceeded beyond the idea of truth born from empiricism a believe that there is an absolute standard of truth, thoug whether we can reach it by an effort of mind is another matte The philosopher believes that we can; the sceptic is not so sur

There is one point of some interest when mentioning pra matism, viz. that pragmatism is more a method of dialectic th the thing itself. If you ask the pragmatist whether he is prepar to believe this theory or that, he asks himself and you if it wou make any practical difference to action which he believes. it makes no difference, then it is immaterial which he believ and he would refuse to consider the subject. Now, does it ma a practical, a pragmatic difference whether we accept the termination of personality by genes or not? It seems to me t it makes all the difference in the world. It would reform the pe system and cut out the revenge motive in the handling criminals. Much of that revenge motive has disappeared fr our handling of our own criminals, but how little it is e shamming dead can be seen when (i) we objectively view foaming at the mouth of our politicians when Nazi atroci are mentioned, and (ii) we subjectively consider our own e tional responses to them. We must look again at the problem

Supposing we agree—and such is my own mentality th cannot help agreeing—that all that we know about mat being obtained throughout sensory apparatus, is subjective exists in our minds, what is the reality behind those sensati It seems to me that we can give no sound logical reasons for

lieving that there is anything there behind the sensations, or in fact to convince anyone who believes that all except his own sensations are illusions that he is wrong. In fact, there are times when I feel that it would not astonish me if I discovered that to be so. Common sense, however, revolts from that position. I cannot help, for instance, believing that apart from my own sensations there is a particular piece of architecture around which I have centred an enormous number of pleasurable emotional reactions—the fountain in the Great Court of Trinity College, Cambridge—and that this particular piece of architecture still exists when I am not there to regard it, or indeed that it would still "be there" if every Trinity don, Bachelor of Arts, undergraduate, college porter and bedmaker vanished suddenly and silently away.

Let us put it in a way more germane to our subject. Common sense allows us to believe that the chromosomes (and possibly even the genes) are there in the cells of the body even if no geneticist is at hand to look at them. They did not spring into existence the first time they were regarded. What is the reality behind our sense impressions, this something which is a permanent possibility of sensation?

Here the philosophers do not speak with one voice. Many of them seem to the writer to try to give reasons for believing that reality is much as we see it, despite the fact that our sensory apparatus seems to add things which are not inherent in the thing itself—e.g. colour. One fairly recent tome on realist philosophy suggested that by the means of scientific investigation we are approaching towards reality by degrees that bring us ever nearer to it. We are supposed to be approaching truth asymptotically, so that although we may never reach it we get a fair correspondence with reality, such as the correspondence, to choose an analogy, between the theme of the song "Father invented the tiddley-pom" with the theme in the finale of Sibelius' fifth symphony. But the author frankly tells us towards the end of his tome that we can learn more of the nature of God from a Beethoven sonata than from all our science. And the prejudices of the writer are such that he says "Amen, to that".

The truly scientific scientist admits that all he is doing is to produce order out of the chaotic mass of sense impressions by means of hypotheses, all of which include "as if" in them. He tells us how things behave but goes no further. He makes no attempt to penetrate behind the sense data he investigates.

That, however, is not enough for the man of "common sense", nor for the philosopher, nor the theologian. These people want to know why these sense data can be arranged by the scientist in such a coherent pattern. What is behind these sense data which gives them such a unity?

There is a school of philosophy, the idealist school, which definitely postulates a reality behind phenomena to which they give various names according to their prejudices. Bishop Berkeley, who held that our sense data are framed by our own minds and would disappear when our bodies disintegrate, explained the permanency of matter by assuming that behind all phenomena there is the divine mind. The universe exists in the mind of God, and it is He who presents to us the sense data by which and in which we live, move and have our being. Kingdon Clifford, the mathematician, postulates "mind-stuff" as being behind our sense-data and giving them coherence. Bradley asserts that this entity is spirit. Hegel calls it the "Absolute". McTaggart, according to a letter in the biography by Lowes Dickinson, speaks of it as Love. (So, too, does Younghusband.) Others call it Wisdom or Truth.

With the exception of Berkeley, these people all seem to put an abstraction at the back of phenomena, an intellectual abstraction, with which one could have no particular relation, especially emotional relations. (Indeed, in conversation with the late J. S. Haldane, whom I admired as a physiologist, respected as a philosopher and liked as a man, I found that the entity he placed behind phenomena was an intellectual conception abstracted from his Presbyterian upbringing. He called it God, but there was no reverence in his voice, and he dismissed the claim of the mystics of being able to get into relation with God as "pathological."[1]) And thus having retreated into an ivory tower, having asserted that all Reality is Spirit, or Truth or Love or Wisdom, they can say to the geneticist with his genes and his determinism "Je m'en fiche".

That is certainly a way of escape from the determinist materialist position, but it is an escape which we may be pardoned for labelling escapism, and will seem to the man in the street somewhat of a trick.

Another way of reaching the position of "Je m'en fiche" is

[1] I was inevitably reminded of the tale of the Russian aristocrat, received into the Presence on his entry into Heaven. "Enchanté de faire Votre connaissance. On a souvent parlé de Vous dans l'église."

the following argument. At the basis in all fields of human endeavour, be it artistic, scientific, philosophic or religious, there is a "judgment". (I take this to mean that there are axioms which one must accept before one can proceed any distance.) This judgment is human, and there is no reason to suppose that a judgment in one field of endeavour is more valuable or true than in another. Therefore, it would seem, when philosophical deductions conflict with those of science, the philosopher may say "je m'en fiche"—as, of course, he has been doing down the ages.

But is the argument sound? There is this difference between art, philosophy and religion on the one hand and science on the other. Though it is true that a judgment may lie at the basis of all fields of human endeavour and that it takes a genius to make any progress in those fields, the end results are not comparable. In science the genius blazes the trail, but the humbler person can follow the trail. Moreover, the follower of the genius using the same or similar techniques *comes inevitably to the same conclusion.* No one, except a crank or two, believes that the earth is flat, that the sun rotates round the earth, that perpetual motion is possible, or that we can produce energy out of nothing. There is general agreement among scientists except, perhaps, at the very verge of the advance of its studies. Further, any ordinary person investigating the theories and discoveries of science comes, almost inevitably, to the same conclusions as the scientist. That is why science has so tremendous a hold upon the modern world.

Far otherwise is it with the other fields of human thought and activity. In art there is no fundamental agreement, nor is the intelligent amateur compelled to the same conclusions as the blazer of trails. To one Raphael, to another Leonardo or Michael Angelo, to a third Titian, and to a fourth Tintoretto will be the greatest painter. Classic and romantic landscapists, impressionists and post-impressionists have their followers and supporters. In music Bach to some is the culmination of that art; to others boredom and an offence. Beethoven to some is the master musician of all time; to others he is coarse, heavy-footed and repetitive. Music died for many with Tchaikovsky; for others it came alive only with Debussy or perhaps not until Walton; and for some it is, whether primitive, classical or modern, excruciating torture. Very few of us would dare to talk openly about our likes and dislikes in music even after years of concert going and amateur study of music.

The same is true of literature. To some the stretch of English

literature between Chaucer and Wordsworth (or even Tennyson) is a dreary waste of verbiage, and as that stretch contains Shakespeare and Milton, such a judgment is somewhat original. To others eighteenth-century literature begins and ends the great age of English literature. And so on and so on. In art it is: *quot homines tot sententiæ.*

In philosophy it is much the same. Each age sees the young schools of philosophy dragging the corpses of their predecessors round the arena, an obsequy which Professor Broad has just accomplished for McTaggart, the last of the Hegelians. And as for theology! The reader who is interested is advised to read the report of the Archbishops' Committee on doctrine in the Church of England—one small branch of Protestantism. It may be true that in all human fields of endeavour a "judgment" is the important starting point, but whereas the edifices built upon those judgments whether in art, philosophy and theology, have little resemblance one to the other, those erected in scientific studies are much alike. The physics of the Braggs bears a close likeness to that of Andrade, and even the genetics, that newest of biological studies, of Morgan bears a distinct likeness to that of Sinnott and Dunn, of Waddington, of Darlington and of Julian Huxley. And there lies the difference between science and the other studies. Scientists do seem to be getting somewhere, whereas the rest seem (to the man in the street) to be getting nowhere. There is no concinnity among their adepts.

So that when the philosopher takes the line of refusing to listen to the findings of science because they are founded on a frail human judgment (as are all other studies), the answer to him is that the sciences all lead in one particular direction, and that each worker feels no marked constraint to stray far afield, the workers in other studies get nowhere in particular and disagree heartily with each other. To which may be answered that it is better to get nowhere in particular than to go straight to perdition. Which is what has been said at intervals to the scientists since the revival of learning.

The science of genetics does seem to point in the direction that all the things which go to make up personality—at any rate in its physical aspects—are rigidly "determined". We are what we are because of our genes, and although the strictly logical scientist will go no further than saying that it appears "as if" the genes determine personality, it is difficult not to assume that it *is* so determined.

But there remains one possibility. Is there no hope of our getting into touch with what is behind the sense perceptions upon which our "knowledge" of "matter" depends? There are people all down the ages who have maintained that there is such a possibility. They are the mystics. They belong to no special race or religion. They may be Hindus, Buddhists, Moslems, Christians (both Roman Catholic, Protestants and Free Church), or they may belong to no specified religion or school of philosophy at all. They claim a "special kind of non-rational experience" in which they attain "some degree of illumination or insight into the essential and normally hidden nature of reality."[1] This knowledge of the essential nature of things is not abstract like intellectual knowing, but concrete, like sense experience. To explain: they receive immediate assurance of the existence of a Something, a Unity, behind the data of the senses, which is as real to them as their own existence. I know, for instance, that "I am" much more certainly than I know that the pen with which I am writing these words "is". I know of the existence of the pen only through the sense impressions I obtain from it. But I need no sensory approaches to tell me that I am. The truth of my own existence is much more immediate to me than the truth of the existence of my pen. The one I get directly, the other I have to obtain through sensory endings in my skin, muscles and joints, or through my eyes, and a complex mechanism of nerve fibres and brain cells of different hierarchies. Now the knowledge which the mystics claim has that same immediacy as my knowledge that I am. The mystic does not feel, he knows. He knows that for some instant of time he has made connection with the reality behind appearance, and he may renew this experience from time to time. And the experience has a quality that makes it convincing, so convincing that it can never thereafter be doubted. It is not too much to say that it may alter the whole tenor of his life, as Paul's life was altered by his experience on the road to Damascus, or as the life of Jesus was altered at the time of His baptism by John in Jordan.

Now let no person shy away from consideration of such experience. It is all very well to say that it is pathological. And it must be admitted that often the mystic is a sick person, either in body or soul or in both. It may be that he has undergone physical and mental disciplines calculated to induce almost any kind of hallucination. He may have fasted or even mortified the flesh by self-torture. He may have spent hours in prayer, in

[1] Stapledon, *Philosophy and Living*, vol. 2, Pelican Books.

ritual or in meditation. The way of the practical mystic is long and arduous, and there is danger on the road. But if success crowns his efforts the result is soul shaking. "All his conduct is irradiated by memory of his vision. He is able to surmount all troubles with fortitude and joy. He behaves with increased wisdom, sincerity, courage and devotion to whatever social ideal he has espoused. He is spurred by a new sense of the reality that informs ordinary phenomenal things. Even sense-perception may reveal unexpected significance to him, significance of the essential nature of the universe. He has an immensely increased capacity for delighting in everything. In particular he may discover an intrinsic worth and lovableness in his fellow human beings, even in those who, in their blindness, pursue evil ends. In short he becomes a much more sensitive, more practical, more alert, more integrated, more genuinely social personality."[1]

Now there is no reason to dismiss offhand the claims of the mystic as fantastic delusions, and my reason for saying that is not so much that there is an extraordinary fundamental likeness between the different accounts given by mystics of their experience, though that fact is cogent, but because mystical experience is much more common than is imagined. In fact it may happen to such people as the reader and the writer, and it is happening to-day as it is happening down the ages. No particular state of mind or body precedes such experiences and many of us brush them aside as meaningless. They are by no means invariably led up to by any discipline, prayer or contemplation. They may come "out of the blue" and even when the recipient is in a negativistic mood. They may come at any age but are perhaps more frequent in late puberty than at other times. And if they come and in any forceful way catch the attention, their effect is twofold—they alter one's outlook on life for the rest of time and they enable one to recognise mystical experience when recounted by another, however different the inevitably stammering description may be. For though these experiences are ineffable, the accounts given instantly speak to one who has had a similar experience.

Mystical experience is at the basis of all true religion. The founders of all the great religions were mystics. Throughout the history of religion the mystic appears from time to time and a great nuisance he can be to the church. Almost naturally poets, painters and musicians are mystics, or have had mystic

[1] Stapledon, *op. cit.*

experiences. Wordsworth, Tennyson and Browning are full of them, and the exemplar is, of course, Walt Whitman. El Greco among painters, Beethoven and possibly Bach and Franck among musicians are mystics. If anyone who understands—or rather comprehends—the mystical experience I am to transscribe below will keep his eyes open when reading modern literature, he will come across case after case of mystical experience. He will find them in unexpected places—e.g. in the late Lady Acland's book about herself and her daughter; in Lowes Dickinson's *Life of McTaggart* and in sundry works of Stapledon.

Here is Tennyson's account of a frequently repeated experience: ". . . all at once, as it were, out of the intensity of the consciousness of individuality, the individuality itself seemed to dissolve and fade away into boundless being; and this is not a confused state, but the clearest of the clearest, the surest of the surest, the weirdest of the weirdest, utterly beyond words—where death was an almost laughable impossibility—the loss of personality (if so it were) seeming no extinction, but the only true life. I am ashamed of my feeble description. Have I not said the state is utterly beyond words?"

Put beside that the experience of a girl remembered in the later tranquillity of adult life.[1] "It had been a good day, with that sort of goodness that accounts for the way so many English folk-songs break into runaway choruses of 'Fol-de-riddle-ido.' We had been out by ourselves gathering primroses—rather uncommon flowers in our countryside, but we had found them in plenty in the place we remembered from last year. There was nothing going on in Milly's head except a sort of 'Fol-de-riddle-ido' feeling as she let her eyes rove here and there, and saw the oaks in their light dressing of golden-bronze, and ash trees still obdurately gaunt, the nimble lambs and their muffled-up old mothers, the fields and grey walls, and the path winding up past the stables to her home on the hillside. All at once, quite without prelude, an astonishing radiance welled up on all these familiar things and in the child herself. They were no longer just themselves, separate objects with edges of their own; they were that radiance, and the radiance was unbounded, glorious love."

I could give examples from the late Sir Francis Younghusband's books, *The Heart of Nature* and *The Living Universe*,

[1] *Good-bye for the Present*, Lady Acland, p. 162.

or from Lowes Dickinson's Memoir on McTaggart, or from a schoolboy's account of two such experiences written within a few hours of the second, but as time and space presses I bring forward a third and last example from Stapledon's *Saints and Revolutionaries*. I choose it because it is quite modern and the author is a sceptical philosopher.

"For sometimes, when I am more than usually awake, I do have a deeply moving experience. There is nothing mysterious, or in any way magical about it. It is just ordinary experience of the world and oneself, only much more lucid and comprehensive. I cannot but regard it as the rightful compass-needle of my whole life. It may happen unexpectedly, in response to some particular and even insignificant event, which now suddenly opens up vistas of significance; or it may come when I try persistently to 'get the feel of' being a self in relation to other selves and the rest of the universe. In either case it brings an unusually precise and poignant awareness both of my present surroundings and of things remote in space and in time. It seems to be simply a very comprehensive act of attention, an attending to everything at once, or to the wholeness of everything at once. And in response to all that this act of attention reveals I feel a very special emotion, which I can describe only as a tension of fervour and peace."

Now I know that at first sight it will seem that there is but little in common between the experiences quoted above, but it will be seen on further examination that there is an emphasis on wholeness and unity, that there is behind phenomena and the world of the senses a reality which unites and permeates all. "It seems to be . . . a very comprehensive act of attention . . .to the *wholeness* of everything at once," writes Stapledon; and Lady Acland: "All at once . . . an astonishing radiance welled up on all the familiar things *and in the child herself*. They were no longer just themselves, *separate* objects with edges of their own; THEY WERE THAT RADIANCE."[1]

[1] If the reader cares to follow up the matter, he will find a chapter devoted to mysticism and mystical experience by William James in his *Varieties of Religious Experience*, giving many examples. And if these examples "mean" anything to him he will find the poetry of Wordsworth, Tennyson and Browning full of such inner meaning. Whitman's poetry is permeated with it and so is that of Tagore and George Russell (A.E.).

> Heaven opens inward, chasms yawn,
> Vast images in glimmering dawn,
> Half-shown, are broken and withdrawn.

This diversity of creatures and things, which normally constitutes the world, in moments of mystical experience "boils down to"—is seen or felt to be—a manifestation of one all-pervading entity, and that "knowledge" is not acquired through the senses but in a way which makes it as certain as the knowledge that "I" am "I". It is direct and immediate, but because our ordinary vocabulary has been developed to describe normal sense data, we have no words which adequately describe a mystical experience. It is, in the derivational sense of the word, ineffable, and all our attempts to describe it are stumblingly inadequate and tinctured inevitably with ideas acquired from the milieu into which we are born and in which we are brought up.

The point is that these mystical experiences are much more common than is generally imagined; they may come to all of us quite unexpectedly and often, but owing to the pressure of circumstances may be unrecognised or treated as pathological. Anyone who has had such an experience can recognise a similar experience in others, however haltingly the experience may be described. The "sceptical philosopher" quoted above goes so far as to say that if we could develop and organise these experiences it would produce a more profound revolution in our conception of things than the work of Einstein.

Those who have attempted such organisation are the mystics. They have appeared in all the great religions and sometimes outside the organised religions, and although the "evidence" they have brought back from their experience has been coloured and informed by the society to which they belong, there is a fundamental agreement in what they say: that behind all phenomena there is a unity.

Above, the point has been made that the reason why science has such a hold over the imagination of people to-day is to be found in the remarkable unity of scientists all over the world concerning the main body of scientific discovery. Physics is no different in Great Britain, in Russia, in Germany or in Japan. Chemistry is the same in Australia, the U.S.A., and in Denmark. And, when closely regarded, the mysticisms of the Hindu, the Buddhist, the Mohammedan or the Christian, seem to say much the same thing. Indeed, I have heard the claim made that the mystics are the scientists of the soul.

If this be so, then just as we accept the findings of the scientists, so ought we to accept, or at any rate to be "open to" the findings, or rather the central core of the findings, of the mystics, especially

as mystical experience is an experience of so many people. No the central core of their findings seems to be that behind the worl of the senses there lies a reality which unites and pervades u all, which we can know and enter into communion with i moments of mystical insight. The nature of this reality is to th mystic of the nature of mind and never of matter. It is true tha he may call it the Absolute, if he is a philosopher; the Worl Soul if he is a pantheist, or God, if he is a theologian. Othe like Younghusband and McTaggart may call it Love and othe Wisdom. The unity the mystic perceives has the nature of spir and never of matter. So if we accept the findings of thes "Scientists of the soul" all that we perceive, however materia it may appear, however it may conform in action to those ab stractions from sense data, which we call "matter", is of the natur of spirit and in the long run must submit to the rule of spirit.

Is there an escape here from the grim deductions at the oper ing of this chapter? I think that there is. At any rate sufficie escape from the pessimism which is the logical end of determinisn And in that possibility we may cheerfully cultivate our garden.

One last point. Though it may be that what we see under th microscope and what we discover concerning heredity and th physiology of brain and endocrine system may be, after all, c the nature of spirit, that does not alter the deterministic pictu sketched by the scientist. But there is, none the less, a possibili of building up a hypothesis which is a compromise between th ultra deterministic view and that of the idealist. It almo certainly involves some kind of dualism, which is a disadvantag but I have yet to find a philosophy into which a type of dualis does not creep.

I approach this hypothesis by continuing the quotation fro Stapledon given on p. 114 above.

"The experience is one which, if I were less sceptical, I mig easily regard as some sort of contact with 'God'. But bei sceptical I refrain from this interpretation. There may be sense in which the old religious language is true, but in our d it is far less true than misleading. I am content, therefore, wi the bald statement that in contemplation I sometimes have intense exaltation about being a self in relation to other sel and the world at large. I am immensely thankful that I and and it exist. In spite of all the frustration and horror of t human world, I am at these times perfectly sure that all o suffering and all our baseness is somehow needed, not for o personal salvation, for of this I know nothing, but for t

rightness of the universe as a whole. Though of course I know only a minute fraction of the universe, and though doubtless my knowledge of this is in many ways wildly false, yet in this state of peaceful exaltation I perceive that even in my superficial and false view there is somehow assurance of the rightness of the whole. I have at the same time a strong conviction that if I, the particular little finite timorous mind, could see the whole as it it really is, I should not, after all, be able to recognise its rightness, but should probably be overwhelmed with horror, so alien would it be even to the most clear-sighted of my actual desires. Nevertheless, because of the tenor of my own immature experience, I am sure that the whole *is* right, with its own dread rightness. In saying this I mean that if I could both *see* the whole as it really is and also steel myself to *feel* it with appropriate courage and sensitivity, I should then recognise its rightness.

"But what about this 'something discovered in the depths of one's own being'? This I interpret as a metaphorical way of saying that in persistent contemplation of myself I discover, beneath all the personal desires which make up the everyday 'I', another desire or will, so alien from the everyday 'I' as to seem indeed another being. It is a detached will for the good, not for my good nor even for mankind's good, but for the good of the universe, whatever that may turn out to involve. I recognise that this will *ought* to be the supreme determinant of my conduct, and in a feeble sort of way I strive to submit my normal self to it. I recognise also that in some sense this will is a potentiality of all minds. Inevitably the awakening of a mind must lead it to this desire, this will. Evidently, then, this will is a very important factor in the universe. But what its metaphysical status is, I do not pretend to know.

"To say all this is to suggest merely my own reaction to an experience which I cannot at all clearly grasp, let alone describe. All that I can say of it is that it gives meaning to life, that it is the supreme consolation, the supreme inspiration, and yet also, strangely, a most urgent spur to action."

No one who has had a mystical experience or who has read at all widely concerning such experiences can fail to recognise a capital example in the above account, though, since it has happened to me of sceptical nature, the report given of it has unusual features. As said above, we note the emphasis on unity, a comprehension of the universe and the individual's relation to that unity. Were the author a Christian the experience would have been expressed in the language of the Christian church.

He would have felt himself to be in union with God and if he belonged to the Society of Friends he would have spoken of that "underlying will or desire" as the Christ or the Light within. There is, too, an emphasis on the consoling and the inspirational power of such an experience coupled with an urgency of action. For your real mystic is often an intensely practical person, or rather becomes, as the result of his experiences, one well able to meet the vicissitudes of normal everyday life.

Nor is there anything unique in the experience quoted in which the author states that there seems to be beneath all the personal desires which make up the everyday "I", another desire or will, so alien from the everyday "I" as to seem indeed another being. This language is strangely reminiscent of St. Augustine's "And being thence admonished to return to myself, I entered even into my inward self, Thou being my Guide . . . and I beheld with the eye of my soul, above my mind, the Light Unchangeable." As said above, it is strangely like the Quaker belief that there is in every man a spark of divinity, there is "that of God" in every man, an inward Light, a seed, a Christ within. And Eastern philosophy, which is a philosophy governed by the intuitions rather than by the mind, states the same: that there is deep within us a self, a soul, which is one with Ultimate Reality. "What that subtle being is of which the whole universe is composed, that is the real, that is the soul THAT ART THOU." Nor must it be forgotten that there is one school of analytical psychology which maintains that after the trappings due to environment and nurture have been stripped away there is an "archaic unconscious" in which we all share and participate.

It may be remembered that in the opening sentences of this chapter a caveat was entered against equating the personality with the true self, the real "I". The "saints" in moments of mystical insight seem to discern beneath the personality an inner self which partakes of the nature of ultimate reality, by whatever name they may call this reality—God, Allah, Yahweh, Brahman, the Absolute, Love, or Wisdom. And this familiar thing which we call self, this assertive, greedy and sensual thing compact of egoism, selfish desires, odd moods and passions and of outstanding characteristics which we dub personality is an imposture and delusion. So I throw out the suggestion that the real "I", the core of our being, that thing so alien from the everyday "I" is a spark, an atom of the fundamental Reality

the Universe, but that its activities are conditioned, moulded and determined by inheritance and nurture. A persona is thrust upon it by our genes and our upbringing. Our personality *is* determined when we react in accordance with those genes and upbringing, but if there is a true integration of the real "I" with the remainder of the self, then in so far we are free agents. It is a commonplace that the core of one's being is often at war with the cupidities and desires, the whims and fancies of the normal self. Man is divided against himself, and only becomes whole when the inner core is integrated with the outer more personal self, when the everyday I becomes one with the inner I. Is it too difficult to believe that the everyday I is the outcome of heredity and environment, fully determined, and that the inner I is a spark, an atom of the reality behind phenomena, and that the workings of the latter through the former determine personality?

This is the doctrine he was wont to teach,
How divers persons witness in each man,
Three souls which make up one soul: first, to wit,
A soul of each and all the bodily parts,
Seated therein, which works, and is what Does,
And has the use of earth, and ends the man
Downward: but, tending upward for advice,
Grows into, and again is grown into
By the next soul, which, seated in the brain,
Useth the first with its collected use,
And feeleth, thinketh, willeth,—is what Knows:
Which, duly tending upward in its turn,
Grows into, and again is grown into
By the last soul, that uses both the first,
Subsisting, whether they assist or no,
And, constituting man's self, is what Is—
And leans upon the former, makes it play,
As that played off the first: and tending up,
Holds, is upheld by, God, and ends the man
Upwards in that dread point of intercourse,
Nor needs a place, for it returns to Him.
What Does, what Knows, what Is; three souls, one man.

ROBERT BROWNING: *A Death in the Desert*, *ll.* 82-103.

BIBLIOGRAPHY

THE reader who wants to go further could hardly do better than start with an amazing book, *Man on his Nature*, by C. S. Sherrington. It is written by an almost omniscient scientist who wields the pen of a poet and is the world's most original investigator of the activities of the nervous system. His account of the cell and its relation to the rest of the body is beyond praise. His description of the development of the eye is a masterpiece, and his picture of the activities of the nervous system in terms of trails of luminosity sheer genius. However much the reader may find himself at a loss with much of the book these passages he should not on any account miss. Perhaps the underlying philosophy is obscure, and some say at times faltering. But anyone who wants to understand the scientist's attitude to his work must read this book.

Much more matter-of-fact accounts of the cell are to be found in Schafer's *Essentials of Histology*, 14th Edition, edited by H. M. Carleton (Longmans, 1938); and the monumental tome, *The Cell in Development and Heredity*, by Wilson (Macmillan and Co.), must be consulted.

For genetics the reader should consult *Principles of Genetics*, by Sinnott and Dunn, 3rd Edition (McGraw Hill, 1939). If he can solve the problems set at the end of each chapter, he has mastered genetics. *An Introduction to Modern Genetics*, by C. H. Waddington (George Allen and Unwin, 1939), is probably the completest statement of the subject, but the writer admits to finding the book very tough reading, as also he does Julian Huxley's *Evolution: the Modern Synthesis* (Allen and Unwin, 1942). He has also been recommended to try E. B. Ford's *The Study of Heredity* and *Heredity for Medical Students*, but so far has not made these books' acquaintance.

For general reading on biology, *The Science of Life*, by H. G. Wells, Julian Huxley and G. P. Wells (Cassell, 1931), cannot be bettered, but it is naturally somewhat out of date. Possibly his reading of this book should precede all except *Man on his Nature*.

The nervous system is a highly specialised subject. Perhaps Wood-Jones and Porteus, *The Matrix of the Mind*, is a good starting-point, followed by the account of the nervous system in any good text-book of physiology (e.g. Starling's *Principles of Human Physiology*, 8th Ed. Churchill, 1941).

The latest and much the most readable book on the organs of internal secretion is Hoskins' *Endocrinology* (Kegan Paul, 1941), which is so charmingly written as to call down the opprobrium of more earnest folk who feel that science should not be pleasantly presented to the public.

On the problems of philosophy involved in a study of the physical basis of personality no one can do better than read Olaf Stapledon's *Philosophy and Living* (Penguin Books, 1939), and follow it up with his *Saints and Revolutionaries* (Heinemann, 1939). *The Scientific Life*, by John R. Baker (Allen and Unwin, 1942), has a good account of the scientist's attitude to his life's work and is genuinely provocative. Naturally, too, one turns to William James's *Varieties of Religious Experience* and to his *Will to Believe* (Longmans, 1903), and the reader must not neglect the various Gifford lectures. On the age-old topic of science versus religion two books have recently been published: A. E. Baker's *Science, Christianity and Truth* (Eyre and Spottiswoode, 1943) and C. E. Raven's *Science, Religion and the Future* (Cambridge University Press, 1943). The writer confesses himself entirely out of sympathy with the former book, but strongly recommends Canon Raven's. Its fairness, good temper, tolerance and charity have much modified the present writer's (innate or acquired) querulousness in this book, and its breadth and depth made him feel quite humble.

GLOSSARY

Allele, One of a pair (or group) of characteristics which cannot appear in inheritance with the other (or others), e.g. normal vision and colour-blindness.
Amnesis. Loss of memory.
Avian. Pertaining to birds.
Axolotl. Newt-like animal from Mexico.

Centrosome. A small body near the nucleus of a cell which apparently controls the direction of its division into two cells when it divides.
Chromosome. The small parts of the nuclear material of a cell which carry the inherited characteristics when cells divide.
Colchichine. A drug derived from the autumn crocus which has the peculiar effect of making a seedling double the number of cell chromosomes.
Corpora striata. A group of three largish striated bodies—the caudate nucleus, the putamen and the globus-pallidus—at and in the base of the brain.
Cortex. A term used in anatomy of the outer part of an organ, its "rind"; e.g. the suprarenal body or the cerebral hemispheres of the brain.
Corticosterone. A hormone, or home-manufactured drug, secreted into the blood by the cortex of the suprarenal body.
Craniosacral. The name given to a set of nerves arising from either the brain or the sacral part of the spinal cord and governing the involuntary activities of the body.
Cystine. An amino acid—one of the component parts of protein —especially important in hair and skin proteins and containing sulphur.
Cytology. The study of the cell.

Desoxycorticosterone. A home-made drug or hormone, manufactured by the cortex of the suprarenal body.
Diploid. Having twice the number of chromosomes found in the sex cells.

Endocrine organs. Organs whic pour their secretions into th blood or lymph stream and nc on to the skin or into the alimer tary tract.
Enzyme. Practically synonymou with "ferment". An ager manufactured by a living cell t bring about chemical reaction which would not otherwise tak place rapidly enough at th temperatures, concentrations c chemicals and pressure com patible with life.
Euphoria. A state or sensatio of extreme well-being.

Filiform. Thread-shaped.

Gamete. A sex cell, whether ma or female.
Gene. The ultimate part of chromosome carrying one i herited characteristic.
Genotype. Any one of the numb of the combinations in which o or more pairs of alleles can t arranged. Thus the yellow cro resulting from the hybridisatic of a pure yellow pea with a gree there is one genotype in the fi generation and three in t second.
Glycogen. A substance found liver and muscle cells, also shell fish; somewhat like star and, on that account, often call animal starch.
Golgi apparatus. An area of t cell-protoplasm frequently r shaped, as large as the nucle and often definitely related position to the nucleus and t direction in which the cell working.
Gonad. The organ—ovary testis—which manufactures t sex cells.

Hæmatoxylin. A dye made fr logwood, used in staining t nuclei and chromosomes of ce
Hæmophilia. A disease in wh the blood will not clot. Used Dorothy Sayers in a detect novel.

Haploid. Having simple, unpaired chromosomes, and therefore having half the number of chromosomes in the body cells.

Hermaphroditism. A state in which the body is part male and part female—normal in oysters, but rare in man.

Heterozygous. Carrying in the body cells each of a pair of alleles. Thus the child of parents one of whom is an albino is said to be heterozygous, though in appearance perfectly normal and indistinguishable from a homozygous person.

Homozygous. Carrying in the body cells only one kind of a pair of alleles. Thus a blue-eyed person is homozygous, as each body cell will contain a pair of chromosomes both of which "carry" blue-eyedness.

Hormone. A "home-made" chemical substance or drug manufactured by an endocrine organ, secreted into the blood or lymph in order to bring about reactions in another organ or set of organs in the body.

Hydroxyprogesterone. A hormone secreted by the yellow body (corpus luteum) in the ovary and controlling events in pregnancy.

Hypothalamus. A portion of the brain in front of and below the third ventricle and the optic thalamus.

Insulin. A hormone secreted by the pancreas to control the utilisation of sugar by the body.

Luteinisation. The formation in large amount of yellow bodies (corpora lutea) in the ovary.

Medulla. The soft inner portions of organs of the body.

Metazoa. Animals with more than one cell.

Micellar. Shaped like a small crumb.

Mitochondria. Thread-like bodies seen in most cells.

Mitosis. The changes seen in the nuclei of cells when undergoing division with the formation of chromosomes.

Moron. A type of idiot.

Morthology. The science which studies the shapes of living organisms.

Nematode. A round worm inhabiting the gut.

Neurone. The name given to a nerve cell complete with all its appendages.

Nictitating membrane. A movable membrane covering the eye between the eyelid and the ball of the eye, well seen in birds and visible in cats. Mr. Gladstone's power of paralysing an opponent by his flashing eyes was attributed at his death to possession of a nictitating membrane. There is no evidence for this.

Nymphomania. Uncontrolled sexual appetite in a woman.

Oestrin. Term used to include all the hormones (with the exception of those which control pregnancy) of the ovary which control the manifestations of sex in the female.

Oestrum. Period of sexual activity in a female.

Octoploidy. Having eight times the number of chromosomes found in the sex cells.

Pancreas. The "stomach sweet bread". A gland secreting digestive juices into the first part of the small intestine and insulin into the blood-stream.

Parathyroids. The "false" thyroids; glands embedded in the tissue of the thyroid gland.

Pellagra. A disease of skin, alimentary tract and nervous system seen in Mediterranean countries and southern parts of the United States, due to lack of nicotinic acid in the diet.

Phenotype. One of the number of ways the appearance of an organism can be varied by one or more pairs of alleles. Thus, in the first generation, a cross of pure yellow and pure green peas will produce one phenotype; in the second generation two only though there will be three genotypes.

Pituitary. A gland between the base of the brain and the roof of the mouth; source of a large number of hormones.

Polyhedral. Many-sided.

Progestin. Term used to include all the hormones of the corpus luteum governing pregnancy.

Pseudohermaphroditism. False appearance of being bi-sexual.

Satyriasis. Uncontrolled sexual over-activity in the male.

Soma. The whole of the body except that part which forms the sex cells; the mortal part of the body as opposed to the potentially immortal sex cells.

Suprarenal body. A gland seated near (in man, *on*) the kidney. It secretes a number of hormones into the blood, one to assist the sympathetic nervous system and others controlling kidney function and sex activities.

Sympathicotony. A state in which the sympathetic nervous system has too great an activity.

Synapse. The place where the branches of one nerve cell make contact with the body of another nerve cell or its branches.

Synaptic. Adjective used of the stage in the first division in the formation of sex cells when the paired chromosomes come together and appear to interchange substance or parts.

Tetraploidy. The condition of having four times the number of chromosomes seen in the sex cells.

Thalamus. A mass of nerve cells at the base of the brain to which most sensory nerve fibres run and terminate.

Thymus. The "neck sweet-bread". An endocrine organ seen at its maximum and best in the young, whose secretion apparently delays the onset of pregnancy.

Thyroid gland. An endocrine organ situated near the shield-shaped cartilage of the Adam's apple. It manufactures a complex of protein and thyroxine, and through this controls the rate at which the tissues of the body produce energy.

Thyroxine. The substance synthesised by the thyroid gland from iodine and tyrosine in the food eaten.

Triploid. Having three times the normal number of chromosomes in the sex cells.

Tyrosine. An amino acid which forms an integral part of most proteins in food.

Vacuole. A space within the protoplasm of a cell, filled with a watery solution.

Vagotonic. State of the body when the vagus and other craniosacral nerves have the upper hand of the sympathetic nervous system.

Viable. Capable of persisting through gestation and being born alive.

Virilism. The state of a woman in whom masculine secondary sexual characteristics have developed.

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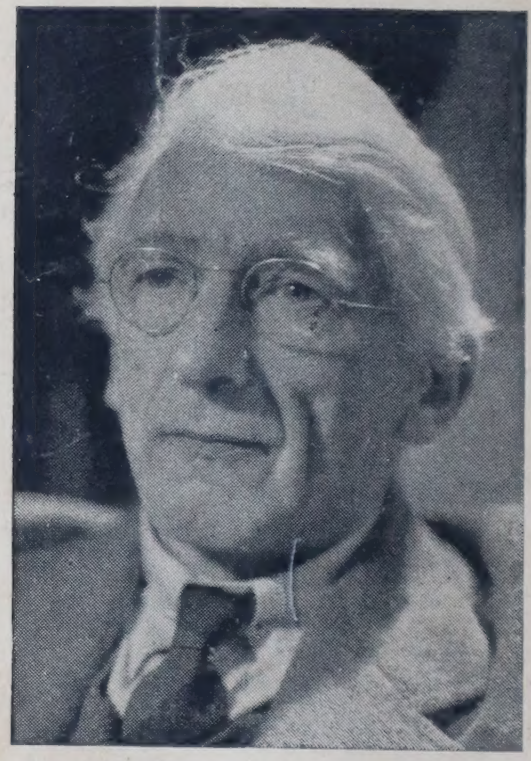

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His hobbies are books, art, photography and music. Always interested in border line and new subjects—e.g. chemical physiology in its earlier days at Cambridge, and, later, dietetics, which has become his main preoccupation. Is convinced that only by developing a scientific approach to life can any progress, material or spiritual, be made. Belongs to no political party, but after the 1935 election swore he would vote for even the wildest communist if the other choice is a representative of vested interests, and now swears that if the ruling classes repeat their trick of 1918 and onwards after the Second World War he will get a soap-box and preach red revolution in the streets of our cities.